Sky and TELESCOPE

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Model of Russian 102-inch telescope

SKY and TELESCOPE

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Vol. XVII, No. 11 SEPTEMBER, 1958

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COVER: A model of a 2.6-meter (102-inch) reflecting telescope exhibited in the pavilion of the Union of Soviet Socialist Republics at the 1958 Brussels Fair. The telescope will be installed at the Crimean Astrophysical Observatory. Its four-ton parabolic primary mirror has a focal length of 10 meters; used as a Cassegrainian, the 130-ton instrument has an effective focal length of 40 meters. Photograph by Alan McClure, Los Angeles, California.

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Rotation of Venus

THE LENGTH of day on the planet Venus is still an outstanding problem. Values as divergent as 22 hours and 225 earth days are currently favored by different observers. The major difficulty is that the planet has a nearly featureless cloud cover, without well-defined markings, such as Mars and Jupiter show.

At Mount Wilson and Palomar Observatories, Robert S. Richardson has made a new attempt to determine Venus' rotation period spectroscopically, by measuring the difference in line-of-sight velocity between the edge of the planet's disk and its terminator (twilight zone). Earlier attempts to use this method in 1903 and 1923 gave inconclusive results in the blue-violet region of the spectrum. For his work, Dr. Richardson used fast red-sensitive emulsions, obtaining his comparison lines from the earth's atmospheric absorption (telluric lines) instead of from an iron-arc laboratory source.

Dr. Richardson employed the Snow solar telescope on Mt. Wilson at the time of Venus' eastern elongation in the spring of 1956. The grating spectrograph gave a dispersion of 0.84 angstrom per millimeter. For other observations in October of the same year, he secured coude spectrograms with the 100-inch reflector, at about 2.8 angstroms per millimeter.

From 28 spectrograms, the California astronomer found that the rotation is so slow as to be masked by the errors of measurement. He interprets his data, in the June issue of the *Publications* of the Astronomical Society of the Pacific, in three different ways:

"a. The direction of rotation is retrograde, with a period between 8 and 46 days, a statement with one chance in two of being correct.

"b. The period is longer than 14 days direct, or longer than 5 days retrograde, a statement with 16 chances in 17 of being correct.

"c. The period is longer than 7 days direct, or longer than 3.5 days retrograde, a statement with 134 chances in 135 of being correct."

If the rotation of Venus is in the retrograde sense, it is from east to west, opposite in direction to the turning of the earth and most of the planets.

Dr. Richardson points out that his results contradict J. D. Kraus' belief that the day of Venus is some 22 hours long, as inferred from radio noise patterns in 1956 from Venus (*Sky and Telescope*, January, 1957, page 122). An alternative interpretation of the radio data, however, would give the period as 13 days.

Although the rotational period of Venus is still uncertain, the orientation of the axis is approximately known from work by Dr. Richardson and by G. P. Kuiper (*Sky and Telescope*, February, 1955, page 131).

Orbits of Visual Double Stars

OTTO STRUVE, *Leuschner Observatory, University of California*

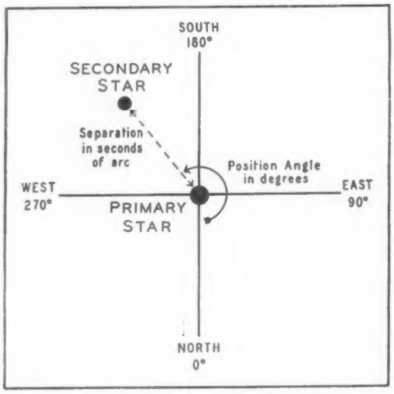
THE FIRST discovery of a visual double star is usually attributed to the Italian astronomer Riccioli, about the year 1650, when he observed the components of Mizar, or Zeta Ursae Majoris. Six years later, Huygens resolved the group of stars now known as the Trapezium (Theta Orionis), and in 1664 Hooke found that Gamma Arietis consisted of two stars.

But, as R. G. Aitken has stated,* "The real beginning of double star astronomy dates from the activities of Christian Mayer and of Sir William Herschel in the last quarter of the eighteenth century." Herschel, more than anyone else, "proved that orbital motion is the simplest and most probable explanation" of the changes in "the relative situation of double stars." He pointed out that Castor and other double stars are real binaries, held together by their mutual attraction.

An observation of a visual binary made with a micrometer at the eye end of a telescope, or a measurement on a photograph of a double star, gives two facts:

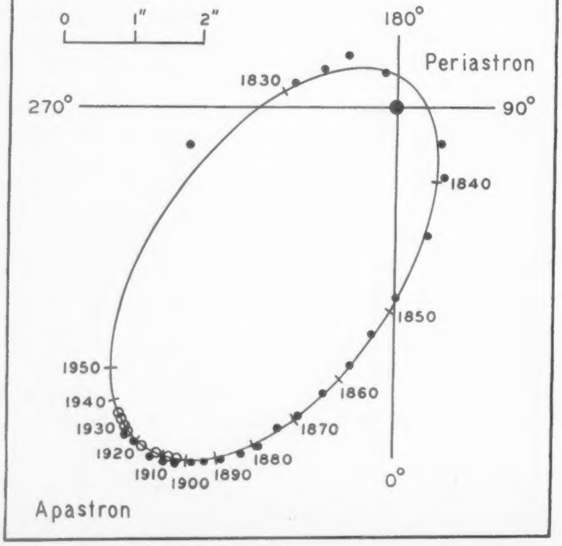
1. The *separation* between the components, expressed in seconds of arc.
2. The *position angle* or direction of the faint star (secondary) with respect to the brighter one (primary), expressed in degrees counted counterclockwise (eastward) from the north.

*R. G. Aitken, *The Binary Stars*, McGraw-Hill Book Co., New York, 1935, page 3.



Position angle and separation, indicated in this diagram, are a convenient way to record a double star observation. In unequal pairs, the brighter star is always chosen as the origin of the co-ordinates.

Because the stars are revolving around each other, the separation and the position angle change from one observing epoch to the next. Such changes generally occur very slowly for widely separated components, more rapidly for those that are close together in space. In binaries more remote from us, of course, the alterations in position are more difficult to detect because the components appear closer together in the sky than they would if their distance away were not so great. For the present discussion, we shall select some relatively easy, well-separated pairs, that have been observed for all or most of a complete orbital revolution.



In this chart of the apparent orbit of the famous binary Gamma Virginis, dots indicate means of visual measurements of the companion's position. The circles are measures from photographs. They are far more accurate, and indicate that visually determined separations tend to be too large. According to recent calculations by H. Wolf, the period of this fine system is 172 years, and periastron will occur in the year 2008. Adapted from K. A. Strand, in the "Annalen" of the Leiden Observatory.

If we plot the position from year to year of the secondary with respect to the primary, the resulting path represents the apparent ellipse of the relative orbit, as it is seen in projection against the background of the celestial sphere.

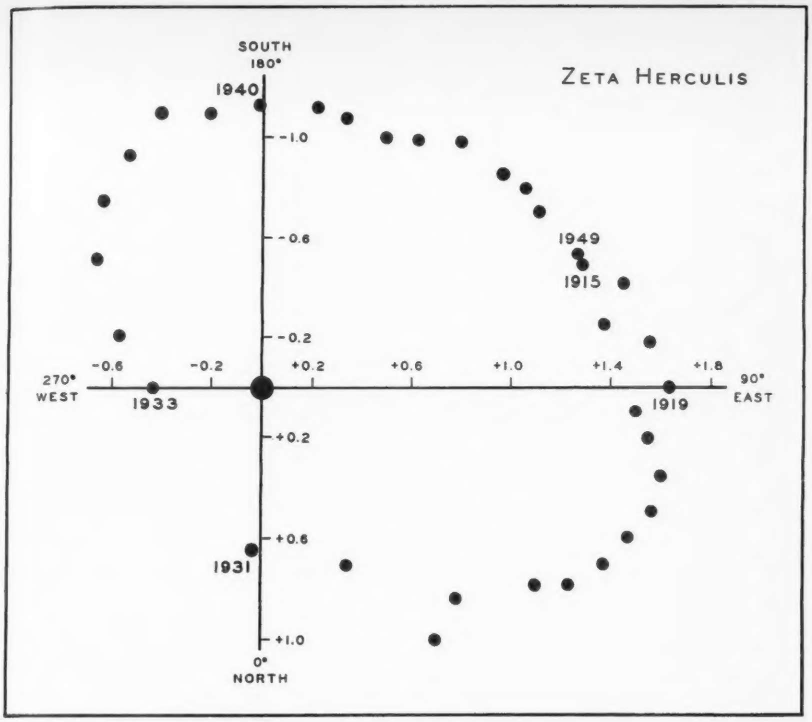
For example, amateurs the world over are familiar with the easy double, Gamma Virginis or Porrima, a beautiful pair of 4th-magnitude stars. As the diagram of its apparent orbit shows, at present the components are well separated, but they are gradually drawing together. Some 125 years ago, when John Herschel and Wilhelm Struve observed this pair, the secondary passed only 0.3 second of arc from the primary and could not be seen separately even in Struve's 9½-inch refractor at Dorpat Observatory. Now, any good 2-inch or 3-inch instrument should easily resolve Gamma Virginis.

But what is the true orbit of such a system? It is, of course, an ellipse, but the plane in which it lies is usually not in the plane of the sky, that is, it is not at right angles to the line of sight. Therefore, the true ellipse is not the same as the apparent ellipse. The astronomer's problem is to deduce the shape and orientation of the true ellipse from the observations that give him directly only its projection on the celestial sphere.

Notice that the primary star of Gamma Virginis is not at either focus of the apparent ellipse. This is true also for Castor, for which the primary is, in fact, quite far off the major axis of the apparent ellipse. This could not be true if the apparent ellipse represented the true orbital path of the companion. (In spite of this, however, Kepler's law of equal areas in equal times is obeyed in the apparent ellipse.)

Let us take a case for which the entire apparent ellipse has been observed and show how, by means of a simple construction, the true orbit may be obtained. We shall use the well-known Zeta Herculis system as our example. It has a 3rd-magnitude primary and a secondary of magnitude 6.5, the period of revolution being 34 years. These stars are at present about 1½ seconds of arc apart, at position angle about 70°.

Accurate measurements of position angle and separation in the Zeta Herculis system extend back to the year 1826; thus the companion has been observed through nearly four complete orbital revolutions.

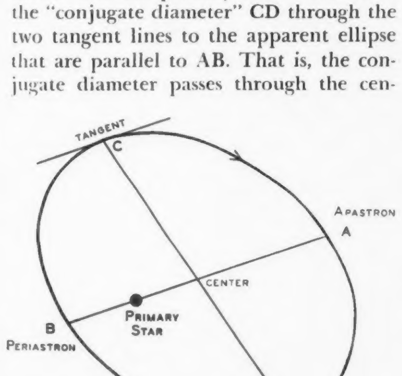


The apparent ellipse for the binary star Zeta Herculis, plotted from annual means of observations for a complete revolution, 1915 to 1949.

This fact allows us to estimate the period directly, from the recurrence of position angle. The companion passed through position angle 120° in the year 1914 and again in 1948, indicating the period as 34 years.

In the accompanying diagram are plotted yearly means of the measurements of Zeta Herculis from 1915 to 1949, taken from a compilation by P. Baize. Although the points show some observational scatter, it is not too difficult to draw the apparent ellipse that they indicate.

Mark the center of the apparent ellipse and draw a diameter AB through the center and the primary star. Next, draw the "conjugate diameter" CD through the two tangent lines to the apparent ellipse that are parallel to AB. That is, the conjugate diameter passes through the center and the two points of tangency on the ellipse.



In the apparent ellipse of Zeta Herculis, after AB has been drawn its conjugate diameter CD is constructed, as explained in the text.

Take a flat sheet of transparent plastic, glass, or a clear photographic plate (unexposed and fixed), somewhat larger than the major axis of the apparent ellipse. In the following description, we shall usually refer to this transparent sheet as "the plastic." With china- or plastic-marking pencil, draw on the plastic a cross of two perpendicular straight lines.

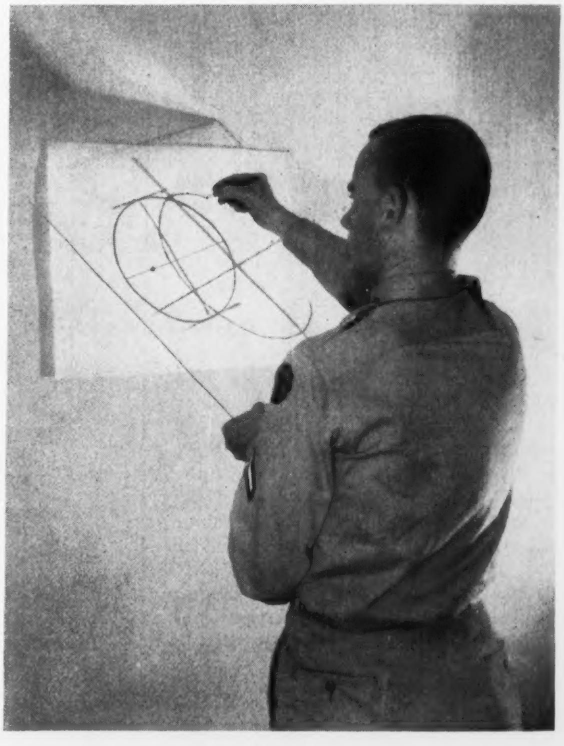
Attach the apparent-orbit drawing to the wall and hold the plastic in front of it, tilting and turning the sheet until the cross on the plastic coincides with the lines AB and CD on the apparent ellipse. There are two and only two orientations of the plastic that give the required coincidence. Both orientations represent solutions of the problem.

To find the shape of the true ellipse, look through the plastic at the apparent ellipse from as great a distance as possible. Then mark on the sheet the outline of the apparent ellipse as it appears when seen through the properly tilted plastic, without moving the sheet.

Be sure that at every instant you look at right angles to the plane of the apparent ellipse. Since in practice it is not easy to fulfill this requirement, I have found it useful to attach to the drawing of the apparent ellipse several match sticks set at right angles to its plane (sticking out from the wall) — one at the center, another at the position of the primary star, and several more at suitable intervals along the apparent ellipse. The matches help the observer shift his eye to each required position by looking along its length as he marks the corresponding point on the plastic.

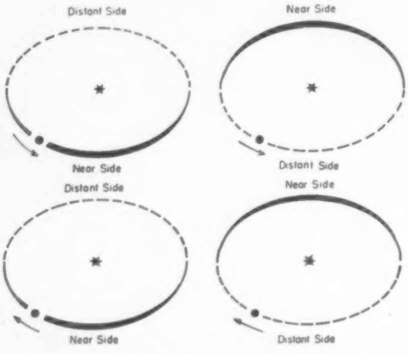
The orientation of the plastic may be found with considerable precision when the cross matches the conjugate diameters on the apparent ellipse. Place a protractor against the sheet at the cross intersection and sight along the protrac-

In this demonstration of the method described by the author, the paper fastened to the wall is a diagram of the apparent orbit of Zeta Herculis, with the two conjugate diameters drawn on it. The operator sights through a glass plate with perpendicular cross lines, tilting the glass until the cross coincides with the conjugate diameters. With the plate still in position, he can then draw the true ellipse directly on the glass. In actual practice, the operator should stand as far back from the wall as possible, and the instructions given in the text should be carefully followed.



tor to read the angle between the line of sight and the plane of the plastic. Subtract this from 90° to obtain i, the *inclination* of the orbit plane to the plane of the sky. For Zeta Herculis, our i determined in this way should come within about a degree or two of the correct value, 49°. (The present convention among double star astronomers is to give the inclination as $180° - i$ for systems like Zeta Herculis where the position angle decreases with time. For this binary we would therefore write $180° - 49° = 131°$.) As we have already seen, there are two possible inclinations, $+i$ and $-i$, both of which give the required fit.

Also, before you disturb the orientation of the plastic, change the position of your eye so that you now look along the plane of the plastic. Mark a line on the



Compare each ellipse at the left with its right-hand neighbor. We cannot tell from inspection which is the nearer side of the apparent orbit, so the true orbit has two possible orientations, each with its own direction of motion.

drawing of the apparent ellipse where the edge of the plastic or glass is seen projected, where the plane of the transparent sheet intersects the plane of the wall. This gives the orientation of the *line of nodes* on the celestial sphere, which may be expressed as the *position angle of the node*, Ω. This is found by measuring with a protractor the angle between the north-south direction and the line that has been drawn in the plane of the apparent ellipse. The result in the case of Zeta Herculis is 48°.

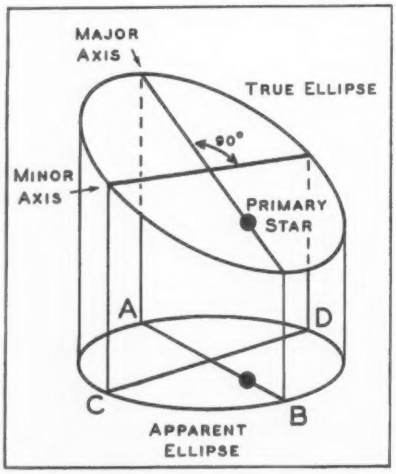
The plastic sheet can now be placed on a desk or table for further study. The ellipse drawn on it represents the true orbit, the cross lines forming its major and minor axes. The primary star is now located on the major axis, and it is easy to demonstrate that it marks one of the foci of the ellipse: The distance of the primary star from one end of the minor axis should be half as long as the major axis. The length of the *semimajor axis*, a, can be measured by the same scale as that used for the drawing of the apparent ellipse. For Zeta Herculis the value of a is 1.4 seconds of arc.

The *eccentricity, e,* of the true ellipse is obtained by measuring the distance from the primary star to the center of the ellipse and dividing it by a. For Zeta Herculis, this distance is 0.7 second, and $e = 0.7/1.4 = 0.5$.

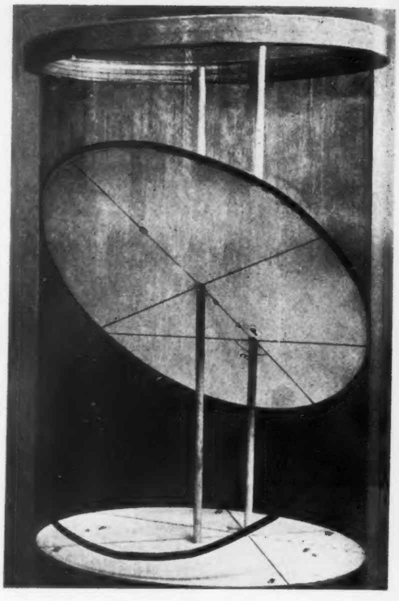
In order to complete the solution, we still require the angle known as the *argument of periastron*, ω, in the plane of the true orbit between the line of nodes and the periastron point, measured in the direction of motion of the companion. To obtain this, draw on the apparent ellipse the line of nodes through the primary star, and sight through the plastic at the proper orientation. Draw a corresponding line of nodes through the primary star position on the plastic. It is now a simple matter to measure ω with a protractor. For Zeta Herculis it comes out 111°.

The procedure outlined above can be explained in terms of a right cylinder constructed with the apparent ellipse as its base. Our problem has been to find a section of the cylinder such that the projection of the primary star lies in one of the foci of the resulting ellipse. Thus, we could have found one of the two sections of the cylinder by trial and error using only the foregoing condition.

In practice, however, it is much more convenient to take advantage of the fact that in the true ellipse the major and minor axes are at right angles to each other. The projection of the major axis onto the apparent ellipse is the diameter AB drawn through the primary star; its conjugate diameter, CD, is the projection of the minor axis of the true ellipse. Hence, all we need to start with is the cross on the transparent sheet of plastic or glass. A few seconds of time are sufficient for orienting the plastic so the axes coincide with the lines AB and CD. If we wanted to, we could then cut out the cylinder at the required angle, producing the true orbit.



In this visualization of orbit relations, the elliptical cylinder is parallel to the observer's line of sight, and the apparent ellipse is a right cross-section. The true ellipse is an oblique cross-section.



A model of a right cylinder devised at Leuschner Observatory by Thomas L. Henyey. The base represents the apparent (projected) orbit of Zeta Herculis, while the true orbit plane is in the center. The vertical rods pass through the primary and ellipse center. A heavy dark line indicates the alternate orientation of the orbit. Leuschner Observatory photograph.

The procedure with the cross on the plastic is, I believe, the simplest and most easily understandable method for obtaining the true orbit of a binary star. But there are a number of short cuts which will make the resulting orbit more accurate.

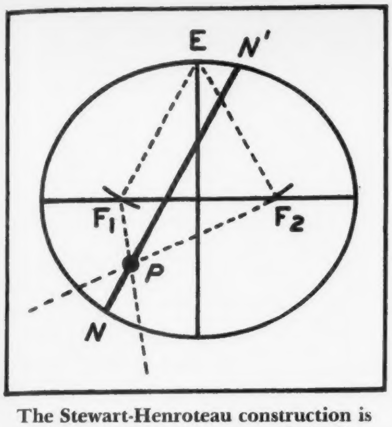
Although the length AB is foreshortened, the factor by which it is reduced is the same for any two intervals of the major axis of the true ellipse. Hence, the ratio by which we had found e is unchanged by projection, and in the apparent ellipse is:

$$\frac{\text{Center to primary star}}{\text{Center to periastron}}.$$

Measurement of this ratio on the apparent ellipse gives directly the eccentricity of the true ellipse. In the case of Zeta Herculis, the ratio is $0''.47/0''.97$, giving 0.48 for e.

A difficult part of the graphical method is, perhaps, drawing a good ellipse while holding the plastic sheet at the proper orientation. With the information above, we actually need only to mark the position of the primary star upon the tilted major axis on the plastic, for the semimajor axis, a, equals the center-to-focus distance divided by e. Furthermore, the distance from the focus to one end of the minor axis is a, as has already been stated. It is a simple matter to draw the required ellipse by means of a string of length $2a$ attached to the two foci.

By graphical methods we can dispense



The Stewart-Henroteau construction is a simple alternative way of finding NN′, the line of nodes of a binary.

with the plastic sheet entirely. We make use of the fact that the semiminor axis of an ellipse is

$$b = a\ (1 - e^2)^{\frac{1}{2}}.$$

If we were to increase all ordinates in the true ellipse parallel to the minor axis by the factor $(1 - e^2)^{-\frac{1}{2}}$, we would obtain a circle (Kepler's *eccentric circle*).

The projection of the minor axis on the plane of the apparent ellipse is the conjugate diameter CD, and the ratios of the line segments are not altered by projection. Hence, if we increase all lines in the apparent ellipse parallel to CD by the same factor $(1 - e^2)^{-\frac{1}{2}}$, we should obtain a new ellipse in the plane of the apparent orbit. Designated by H. J. Zwiers as the *auxiliary ellipse*, it is actually the projection of Kepler's eccentric circle upon the apparent orbit plane. The major axis of the new ellipse is equal to the diameter of Kepler's eccentric circle, and the latter is by the nature of its construction equal to the major axis of the true orbit.

Moreover, the orientation of the major axis of the auxiliary ellipse (in the plane of the apparent orbit) gives the line of nodes. But another convenient procedure for determining this orientation is given by Stewart and Henroteau in *Popular Astronomy* for 1925 (Vol. 33, page 304):

Find the foci of the apparent ellipse. This can be done by drawing its longest diameter and its shortest one, these crossing at right angles. Place a drawing compass at an end of the short diameter and swing an arc with a radius equal to half the length of the long diameter: it will cut the latter at the foci.

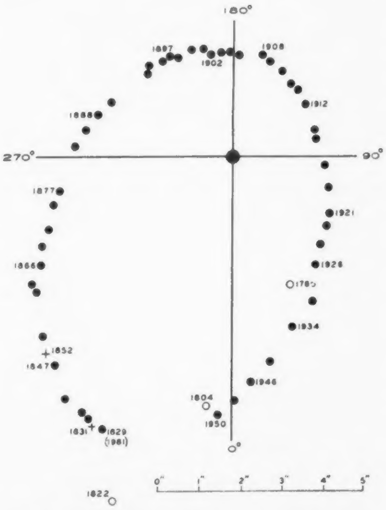
Draw straight lines from each focus to the primary star and bisect the exterior angle formed by these two straight lines. This is the orientation of the line of nodes. The proof of this procedure is simple when the primary star is on the major or minor axis of the apparent ellipse. It is a little more complicated when the primary star occupies an arbitrary position, but it gives the same result as the procedure with the transparent plastic. Remember that the line of nodes defines an orientation only, and that any line parallel to one found by these methods is also the line of nodes. It is conventional to draw the line of nodes through the primary star.

For the reader who would like to try his hand at solving another binary-star orbit, a somewhat more difficult case than Zeta Herculis is that of Alpha Centauri, the nearest star to the sun. The apparent ellipse can be plotted from the following position angles and separations quoted by W. S. Finsen, to which a few more recent observations have been added.

Alpha Centauri

Year	*P. A.* °	*Sep.* ″	*Year*	*P. A.* °	*Sep.* ″
1853.5	270.6	4.50	1894.5	207.3	20.67
1857.5	321.7	4.17	1901.5	210.7	21.89
1860.0	345.9	5.35	1910.2	215.4	19.52
1863.5	3.4	7.58	1915.3	218.7	17.21
1870.5	21.2	10.38	1922.9	226.3	12.38
1873.0	26.4	9.52	1930.5	247.8	6.47
1875.0	33.5	7.13	1933.4	269.4	4.68
1876.5	48.6	4.20	1936.4	308.0	4.06
1877.5	76.7	2.19	1939.6	341.9	5.49
1878.5	142.7	2.10	1942.1	358.1	6.73
1879.5	176.8	3.50	1945.1	9.9	8.76
1881.0	188.8	6.55	1949.5	19.2	10.58
1885.0	200.0	13.16	1952.4	25.4	9.48
1889.5	204.1	17.82	1956.4	48.2	3.85

For Alpha Centauri, the transparent-plastic method should yield approximately: period, 80 years; inclination, 79°; position angle of node, 25°; argument of periastron, 52°; eccentricity, 0.52; and dates of periastron passage, 1876 and 1956. These are rounded-off values from the very precise orbit determination by Finsen, who is well known for his work on double stars.



The apparent orbit of the visual binary, Xi Bootis, an easy pair in small telescopes. The stars are magnitudes 5 and 7. The elements of the true orbit are: period, 150 years; inclination, 140°; position angle of node, 168°; argument of periastron, 24°; eccentricity, 0.51; semimajor axis, 4.9 seconds; and date of periastron, 1909.

QUESTIONS... FROM THE S+T MAILBAG

***Q. Do meteorite fragments from the Barringer Crater in Arizona show Widmanstätten figures when etched?**

***A.** In many cases, as may be seen in numerous specimens from this crater which are displayed in museums and planetariums.

Q. Would light from a star at the moon's edge be bent by the moon's gravity, as predicted by relativity theory and observed for stars near the totally eclipsed sun?

A. Yes, but the bending would be much too slight to be detected. Even in the case of the sun, which is 25 million times more massive, this deflection is only about $1\frac{3}{4}$ seconds of arc at the sun's limb.

Q. What are the wave-length ranges of the colors of the spectrum?

A. Red extends from a little longer than 7000 angstroms to about 6200; orange is 6200 to 5900; yellow to 5750; green to 5300; blue-green to 4900; blue to 4600; indigo to 4300; and violet to about 3900.

Q. How bright are the satellites of Uranus?

A. Their magnitudes at mean opposition are: Ariel, 15.5; Umbriel, 16; Titania, 14.0; Oberon, 14.2; and Miranda, 17. They are more difficult to see than these numbers suggest, because they are always within a minute of arc of Uranus, which is eight to 11 magnitudes brighter.

Q. What is Roche's limit?

A. Roche's limit is the minimum distance from a planet at which a liquid satellite would not be torn to pieces by the tide-raising forces of the planet's attraction. For a satellite of the same density as its primary, the limit is 2.44 times the planet's radius. The rings of Saturn lie within Roche's limit for that planet, but its innermost satellite, Mimas, lies outside.

Q. What is the largest asteroid?

A. Ceres, the first minor planet discovered. It is about 480 miles in diameter.

Q. Is the 200-inch Palomar reflector ever used for visual work?

A. Very rarely, for specialized programs such as measuring the size of Pluto. The telescope is designed primarily for photographic, spectrographic, and photoelectric observations.

W. E. S.

*This question is repeated from page 457 of the July issue to correct the misquotation of Dr. John S. Rinehart. The mistake was pointed out by Frederick C. Leonard, University of California, Los Angeles, and H. H. Nininger, American Meteorite Museum. Small specimens near the crater do not show good Widmanstätten patterns, while meteorites picked up at greater distances do. Dr. Nininger discussed this topic at length in *Popular Astronomy*, April, 1950, page 169.

The 36-inch reflecting telescope of Washburn Observatory is seen through the opened dome of this new building, located on a broad hilltop in southern Wisconsin. The instrument replaces the historic 15.6-inch Clark refractor in Madison, and will not only specialize in photoelectric measurements of colors and brightnesses of stars, but will make observations with a fast spectrograph. University of Wisconsin photograph.

Wisconsin's Pine Bluff Observatory

THE NEWEST American astronomical station to go into operation is Washburn Observatory's installation at Pine Bluff, 15 miles west of Madison, Wisconsin. The dedication of the new observatory and its 36-inch reflecting telescope on June 30, 1958, was a highlight of the 100th meeting of the American Astronomical Society at the University of Wisconsin.

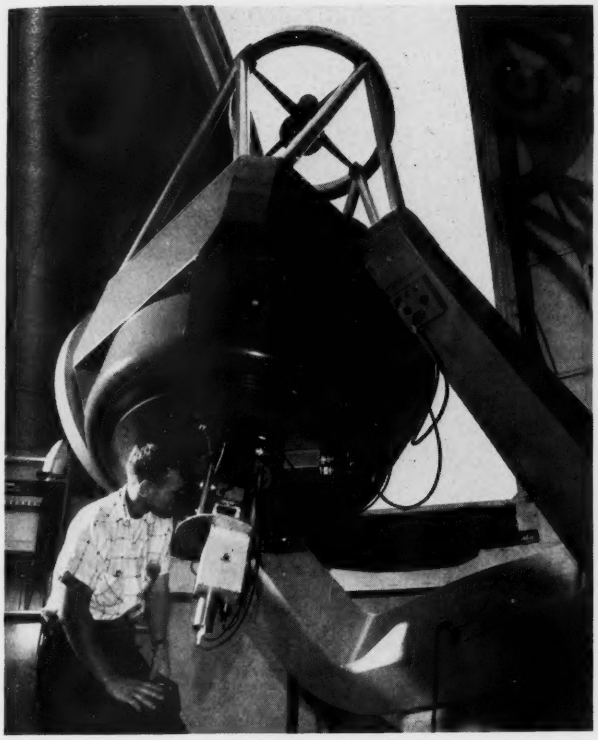
This is the first major instrumental addition to Washburn Observatory since the 15.6-inch refractor was erected in 1879, when it ranked third in size in the United States. For the past 35 years, the main work with this instrument has been photoelectric measurements of star brightnesses and colors. But the location of the observatory on the university campus has become less and less favorable, as city lights and smoke increased.

The Wisconsin Alumni Research Foundation provided over $200,000 for the new telescope, erection of the observatory buildings, and acquisition of the 53-acre site. It is located 1,100 feet above sea level on an open hilltop, surrounded by low-lying woods and pastureland. Ground was broken in April, 1957, for the one-story brick building, about 45 feet square. It is surmounted by a 25-foot steel dome built by Astro-Dome, Inc. A smaller building is for a 12-inch reflector.

Like other instruments intended especially for photoelectric observing, the 36-inch is often called a light collector rather than a telescope. It is of the Dall-Kirkham type, with an ellipsoidal primary mirror 36.0 inches in diameter and a 9.8-inch spherical secondary. Outwardly, the instrument resembles a Cassegrainian, light from the secondary passing through a perforation in the primary to the focus about two feet behind it.

The completed pyrex mirror weighs over 400 pounds. It was figured by Fred Pearson, of the optical shop at Yerkes Observatory. The mounting was built by Boller and Chivens. Much auxiliary equipment, including frequency controls for the telescope drive, was built by members of the observatory staff.

The plans for the future are a continuation and broadening of the photoelectric



Two pictures of the Pine Bluff 36-inch reflector, which has optics of the Dall-Kirkham type. At the left, John S. Neff is working with a photoelectric photometer, and at the right is Arthur D. Code, Washburn Observatory's new director. In the view down the open tube, notice the reflection of the secondary assembly in the surface of the 36-inch primary mirror, which is surrounded by a cylindrical light baffle. University of Wisconsin photographs.

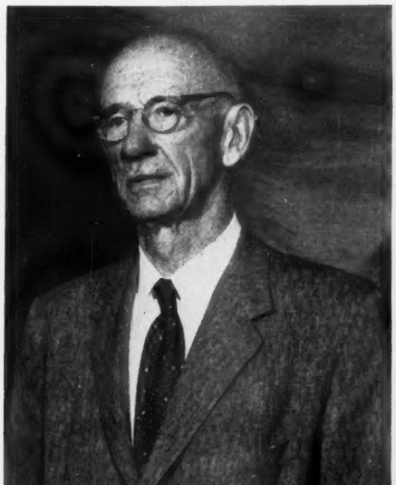
work of Joel Stebbins, who was director of Washburn Observatory from 1922 to 1948, and has since been a research associate at Lick Observatory. Dr. Stebbins gave the chief address at the dedication, reviewing the 80-year history of Washburn Observatory.

Washburn's first director was James C. Watson, well known for his classic treatise *Theoretical Astronomy,* but he died suddenly after only two years at Wisconsin. His successor was Edward S. Holden, who in 1883 led a government eclipse expedition to the South Pacific to search for an intramercurial planet. He asked S. W. Burnham, world-famous amateur discoverer of double stars, to join the staff; with the 15.6-inch refractor Burnham found a hundred new doubles. After four years Holden left to become director of Lick Observatory in California.

The third director was George G. Comstock, who served for 35 years. His extensive work on double stars led to the determination of proper motions of faint stars, down to the 12th magnitude. Dr. Stebbins, in his talk, said Comstock's work demonstrated that "these stars as a class appear faint because they are intrinsically so, and not alone because of greater distance. This idea was the forerunner of the modern concept of dwarf and giant stars."

Dr. Stebbins was the first astronomer in America to exploit the vast astronomical possibilities of the newly invented photoelectric cell, beginning his work at the University of Illinois before he came to Wisconsin in 1922. Describing subsequent events, he said,

"At the Washburn Observatory . . . the whole field of photographic research was skipped, and we jumped directly from visual to photoelectric methods. For the past 35 years the energies of the staff have been confined to the application of the photoelectric cell to astronomical observations. Among the fields of investigation have been the detection of small variations in the light of stars, studies of eclipsing and pulsating stars, measurements of magnitudes and colors of stars, and studies of interstellar material from the effects of selective absorption in space. My colleague, C. M. Huffer, has been associated in all this work from the beginning, and A. E. Whitford for about 25 years.



Joel Stebbins, former director at Washburn, and photoelectric pioneer.

"An epoch-making event took place here when Whitford devised the combination of a photocell and an amplifier in a vacuum tank, mounted it on a board, and pointed it through a tube out of a basement window at the pole star. After successful measures of Polaris, the device was transferred to the 15.6-inch refractor where it worked without difficulty. We used to say that this photometer alone, without a telescope, would detect a candle a mile away. We said this so often we felt constrained to try it at least once with a real candle at a real mile.

"When we did so by setting up a standard candle on Picnic Point, a mile across the lake from the observatory, we found that, with no optical aid except a blank tube to eliminate stray light, the photocell would not only give a conspicuous response in galvanometer current when exposed to the candle, but would show a

detectable effect when the light was cut down to about one-fiftieth of a candle at the mile, or, say, a candle at seven miles.

"Since the effective aperture of the cell was about one inch, it followed that on the 15.6-inch refractor the limit of detection would be a candle at about 100 miles. Now, with the new installation on the 36-inch reflector we should be able to detect a candle at 1,000 miles. Here we allow a factor of five for the larger telescope and of about 20 for the improved light receivers and techniques. If we extrapolate into the future, improvements by a factor of 100 every 25 years should be satisfactory all around."

Succeeding Dr. Stebbins as director, Dr. Whitford planned and supervised construction of the Pine Bluff station, but he has now followed Holden's example, becoming director at Lick Observatory on July 1, 1958. Arthur D. Code, who is the new Washburn director, states that the 36-inch instrument will have a fast spectrograph with which the spectra of astronomical objects can be either scanned photoelectrically or recorded photographically.

"This combination," he has explained, "should make the facilities at Pine Bluff particularly satisfactory for observations of diffuse nebulae and extragalactic systems. The major part of our program will concern problems for which the scale [16.5 seconds of arc per millimeter at the Cassegrainian focus] makes the telescope more suitable than those of larger aperture."

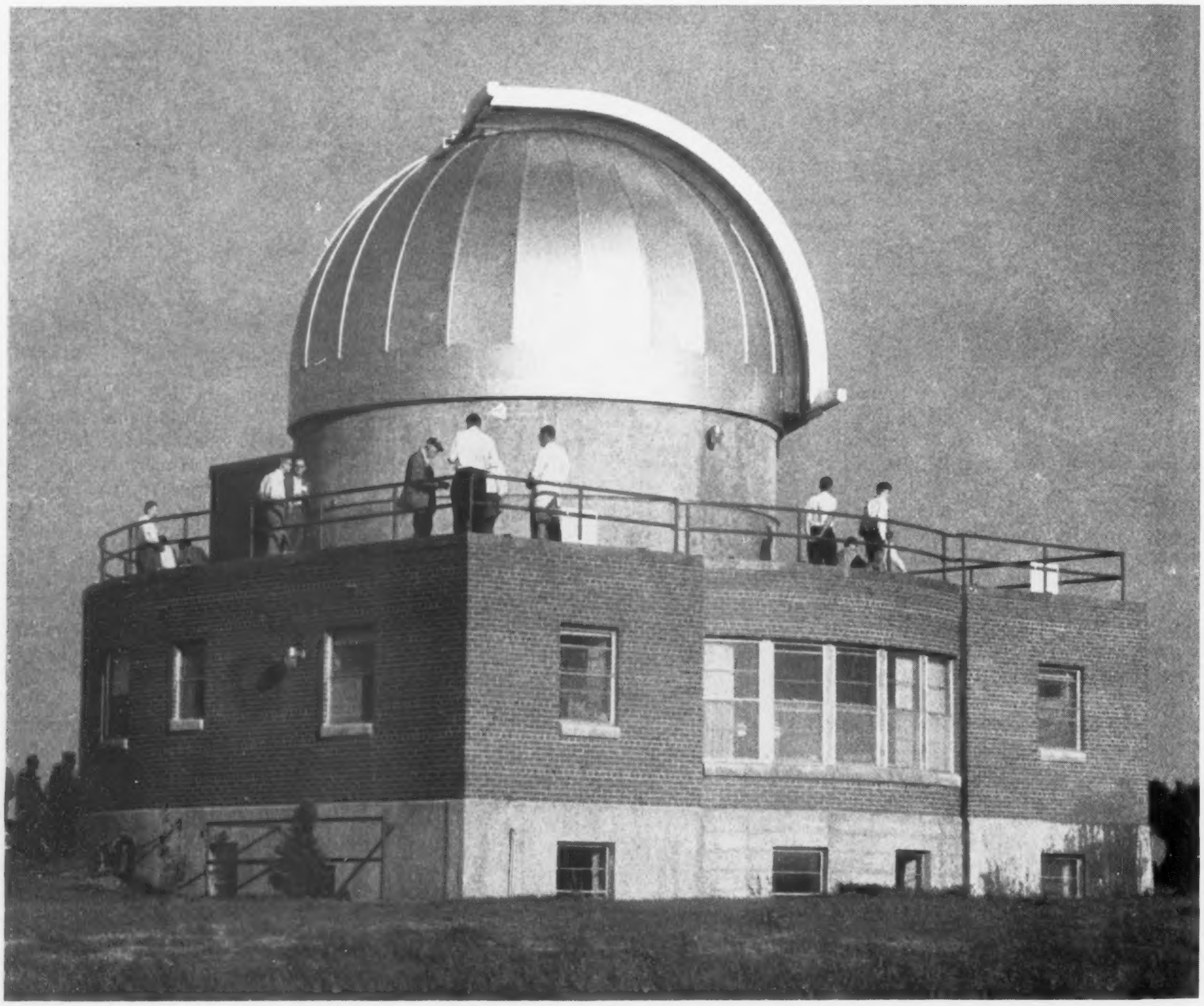
Another important study will be determining the absolute energy distribution in stellar spectra. For this purpose, a 75-foot tower has been erected about 1,000 feet from the observatory site. On this tower standard lamps and black-body sources may be mounted, making it possible to compare the light of the stars directly with known radiation standards.

On the Wisconsin campus, where student interest in astronomy is very great, the department of astronomy will soon be transferred to new quarters, while the alumni are given the use of the original building on Observatory Hill. A new wing is being built on Sterling Hall, which houses the physics department. On the sixth floor the astronomers will have offices, classroom and teaching laboratory, electronic, optical, and machine shops, library and conference room, darkroom facilities, and on the roof two telescopes and a transit instrument. The Spitz planetarium, now in operation elsewhere on the campus, will be housed there also, with a 24-foot projection dome.

In addition to Drs. Code and Huffer, the Washburn Observatory scientific staff includes Prof. D. E. Osterbrock, Dr. T. E. Houck, and Dr. R. C. Bless.

METEORITICAL SOCIETY

The 21st meeting of the Meteoritical Society is to be held August 31-September 1 at Winslow, Arizona. The scientific sessions, open to the public, will begin at 9 a.m. on Sunday at the La Posada Hotel. A field trip to the Barringer meteorite crater will be made on the next day.



Members of the American Astronomical Society inspect the Pine Bluff Observatory at its dedication, June 30, 1958. This view is of the western side of the building, opposite to that shown on page 552.

NEWS NOTES

RECURRENT NOVA IN OPHIUCHUS

A spectacular stellar explosion that caused a faint star to increase a hundredfold in brightness within a day was recorded by variable star observers around the world in mid-July. This star is the recurrent nova RS Ophiuchi, which previously had briefly attained naked-eye visibility in 1898 and 1933.

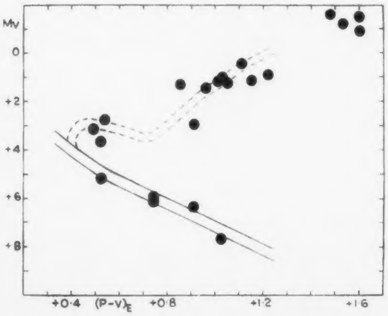
On that second occasion, a codiscoverer was Leslie Peltier of Delphos, Ohio, who kept a close watch on the star, normally between the 11th and 12th magnitudes, in hopes of detecting a third outburst. On July 12, 1958, he observed it as magnitude 11.1, and the next evening it was found to be 6th magnitude by Cyrus Fernald, Wilton, Maine; Clinton Ford, Suffield, Connecticut; David Rosebrugh, Meriden, Connecticut; and F. M. Bateson, Rarotonga, Cook Islands. Mr. Peltier himself independently discovered the change on July 16th.

According to reports received by the American Association of Variable Star Observers, the increased brightness of RS Ophiuchi was also observed in South Africa and in Iran during the next few days. If the star follows the same pattern of light changes as in 1898 and in 1933, a rapid fading should now be in progress. Mr. Ford's estimates indicated a decline to magnitude 6.8 by July 20th.

NEW STELLAR STREAM

The two bright stars Zeta Herculis and Beta Hydri, though far apart on the sky, are moving in space with equal velocities along parallel paths, it has been noted by Olin J. Eggen of the Royal Greenwich Observatory. These stars are both traveling toward a point in the constellation Lepus, at a speed of 74.5 kilometers per second relative to the sun.

This finding led Dr. Eggen to search through catalogues of high-velocity stars for other objects sharing this space motion. In the British publication *Observatory* he presents a list of 22 stars probably belonging to the Zeta Herculis group.



O. J. Eggen's color-luminosity diagram for members of the Zeta Herculis stream of stars. The vertical scale is visual absolute magnitude, the horizontal one color index. More luminous stars are toward the top, red ones to the right. The four stars plotted at the upper right are M-type giants. Reproduced from the "Observatory."

He could then calculate individual distances for these stars, by comparing the observed proper motion and radial velocity of each star with the space motion of the group. (The process is that described by Otto Struve in *Sky and Telescope*, October, 1956, page 535.) The Zeta Herculis group, it appears, is a very large and sparse system, in form like the Ursa Major stream rather than the more compact, moving cluster in Taurus.

Dr. Eggen plotted the color indices and absolute magnitudes for stars of the Zeta Herculis group in the diagram reproduced here. The two solid lines represent the main sequence as indicated by the Praesepe cluster in Cancer. The dashed strip is the sequence of subgiant stars, as found by H. L. Johnson and A. Sandage for the very old open cluster Messier 67.

CHANGES IN THE SUN'S MAGNETIC FIELD

With the aid of a newly invented, highly sensitive magnetograph, the father-and-son team of Harold D. and Horace W. Babcock began in 1952 systematic observations of the general magnetic field of the sun. (See page 423 of October, 1954.) Up to 1956, this field had a strength of about one gauss, and was limited to high solar latitudes, beyond 55° north and 55° south. The polarity was positive in the sun's north polar regions and negative in the south – unlike the earth's field.

A continuation of these observations at Pasadena, California, and since May, 1957, also on Mt. Wilson, has been reported to the National Academy of Sciences by Harold D. Babcock and William C. Livingston. They have found striking changes. By June, 1957, the intensity had decreased irregularly, and the field near the sun's south pole had reversed its polarity. Since then, the average intensity for the north cap has been +0.2 gauss and for the south cap +0.6.

This alteration took place about three years after sunspot numbers were at minimum. The California scientists suggest that the variations in the sun's poloidal magnetic field reflect the large-scale patterns of circulation associated with the 22-year cycle in the magnetic properties of sunspots.

VISITING PROFESSORS PROGRAM RESUMES

During the coming school year, the American Astronomical Society will continue its program of visiting professors in astronomy for colleges and universities (see *Sky and Telescope*, February, page 181, for details of the original plan).

There will be about eight astronomers taking part in the expanded program, supported in part by the National Science Foundation. Further information may be secured from Dr. William Liller, University of Michigan Observatory, Ann Arbor, Mich.

IN THE CURRENT JOURNALS

THE SURFACE TEMPERATURE OF THE MOON, by R. H. Garstang, *Journal* of the British Astronomical Association, May, 1958. "The conclusion from all this work is that the surface of the moon is covered with dust. . . . The extremely low values of the thermal conductivity provide yet another confirmation of the absence of any appreciable lunar atmosphere."

INSIDE THE PLANETS, by Rupert Wildt, *Publications* of the Astronomical Society of the Pacific, June, 1958. "If overconfidence in our reasoning has not betrayed us, we are looking deeper into the recesses of the Jovian planets than into the ground we walk on."

HOT SPOTS IN THE ATMOSPHERE OF THE SUN, by Harold Zirin, *Scientific American*, August, 1958. "The high temperatures of the corona, especially its hot spots, offer at present the most promising lead to an explanation of the sun's production of cosmic rays."

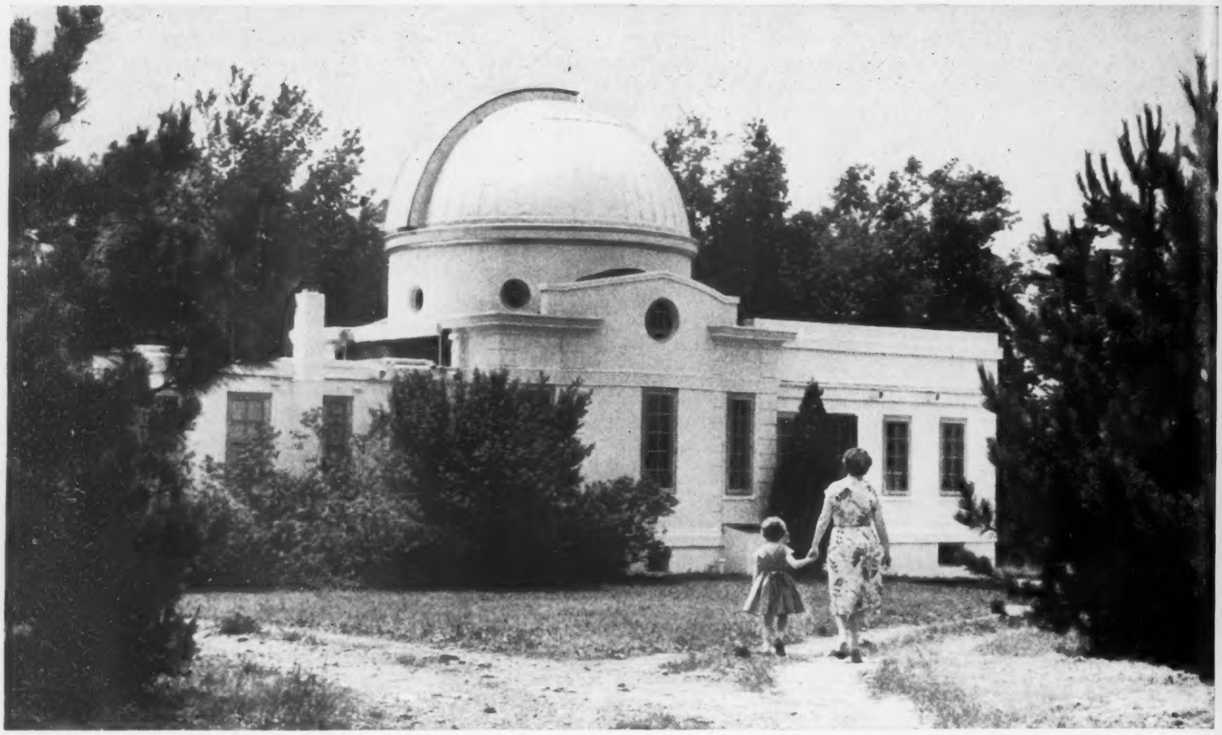
BREAKUP OF STAR CLUSTERS

As a galactic star cluster moves through our Milky Way system, encounters with field stars tend to add internal energy to the cluster, so a slow "evaporation" of its stars takes place. Eventually the cluster will become entirely dispersed. Careful calculations by several astronomers show, however, that the disruption by this process is too slow to account for the observed great rarity of clusters older than about 500 million years.

Evidently some other, more effective means of breaking up the open star clusters is also operating. Lyman Spitzer, Jr., Princeton University Observatory, has now found that successive encounters with extended interstellar gas clouds is just such a process.

His computations show that, for a cluster five parsecs in diameter, the rate of increase of its internal energy resulting from gas cloud encounters will be about 30 times greater than from interactions with field stars. The Princeton astronomer finds that a cluster with an average density equivalent to one solar mass per cubic parsec would dissociate into separate stars in about 200 million years. The stars of relatively smaller mass in a cluster will be lost more rapidly.

The details of this investigation were reported in the *Astrophysical Journal* for January, 1958.



Mrs. G. R. Wright and her daughter at Fuertes Observatory of Cornell University. This building, containing a 12-inch Warner and Swasey refractor (Brashear lens), was built in 1919. It also houses a 12-inch horizontal reflector, and a 25-inch reflector is partially completed. A 4-inch zenith telescope and a 4-inch meridian transit are in rooms to the left in the picture, while a small planetarium is at the right.

CONVENTION IN ITHACA

CORNELL UNIVERSITY'S beautiful campus in Ithaca, New York, was the scene of the 12th general convention of the Astronomical League over July 4th weekend. More than 200 amateurs, including 35 members of the Association of Lunar and Planetary Observers, enjoyed the excellent program set up by the host society, the Astronomy Section of the Rochester Academy of Science.

First arrivals began registering on Thursday afternoon, July 3rd, in one of the university's modern dormitories. A room had been set aside for exhibits of astronomical products by firms which are supporting members of the league. In addition, the Atlanta juniors sent a model of the stars in the solar neighborhood, the ALPO had a colorful display of its members' work, and there was an operating seismograph constructed by John Ruiz, Dannemora, New York.

The evening was taken up with the league council meeting and informal get-togethers. Although clouds prevented astronomical observing, a spectacular fireworks display at the university provided an artificial substitute.

President Russell C. Maag, Sedalia, Missouri, called the convention to order at 10:30 o'clock Friday morning. Welcoming speeches were made on behalf of Cornell by Dr. Francis E. Mineka, dean of the college of arts and sciences, and by Dr. R. William Shaw, chairman of the department of astronomy.

At the roll call of societies, executive secretary Wilma A. Cherup of Pittsburgh, Pennsylvania, reported that the league now includes 110 regular societies and 21 junior groups, with a total individual membership of 7,000. There are also 33 members-at-large, two affiliate organizations, and 15 supporting members.

The first afternoon session was devoted to the International Geophysical Year and artificial satellites. The three scheduled papers dealt with supplying acquisition data to satellite tracking teams, early MOONWATCH team performance, and the Phototrack and Moonbeam projects. Following the group photograph, Dr. C. W. Gartlein of Cornell, who heads the American IGY program of visual aurora observing, showed maps of the overhead location of auroras, and discussed their interpretation.

Dr. Ian Halliday, Dominion Observatory, Ottawa, reported on the extensive photographic, visual, and radar studies of meteors, sponsored by the Canadian government. He told of valuable work by amateur observers in the program.

The newly formed Science League was described by Nelson M. Griggs, Boyds, Maryland. Jane Shelby, Teaneck, New Jersey, recounted her orbit calculation for Sputnik I, in a paper that had helped her win a $5,000 scholarship in the Westinghouse national science talent search. Mr. Ruiz gave a spirited account of his photoelectric brightness observations of the fast-changing variable star, 12 Lacertae.

Another evening of cloudiness prevented a scheduled observing session at Fuertes Observatory on Friday (it was the same on Saturday evening). Instead, William G. Cleaver of Mt. Carmel, Connecticut, showed many beautiful astronomical slides and a color movie of past meetings of the American Association of Variable Star Observers.

The Saturday morning session on instrumentation produced some noteworthy talks. Of particular interest was an unusual equatorial mounting designed by David W. Cogswell, West Springfield, Massachusetts, for his 6-inch Maksutov telescope. Excellent celestial photographs, obtained with a 12-inch f/4.3 reflector, were displayed by George T. Keene, Rochester; and John E. Schlauch of the same city talked on the Dall null test for paraboloids. Other speakers discussed flo-

The 12th general convention of the Astronomical League at Cornell University, Ithaca, New York, July 3-6, 1958.

tation for perforated mirrors, the Maksutov telescope, and the Utica Amateur Astronomers' radio telescope project. This was followed by a brief ALPO session, with papers on lunar colongitude, selenomorphology, and domes.

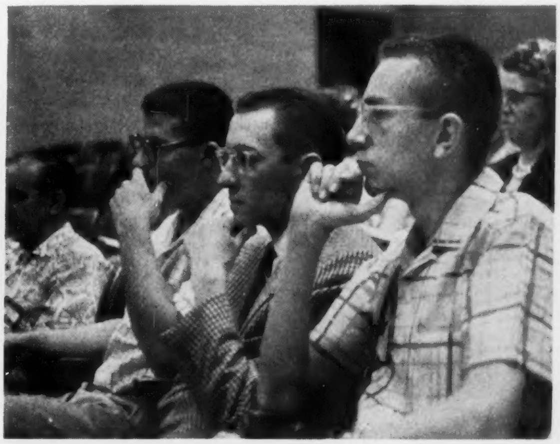
At a lively afternoon junior session, Beth Beyer, Pittsburgh, told of her experiences with the 13-inch refractor at Allegheny Observatory; Joseph Lupia, Clinton, New York, spoke on the ages of stars; Daniel Kleinman, Louisville, Kentucky, on what makes astronomy; and Clarence E. Johnson, former junior activities chairman, on the role of the junior astronomer. The star model by the Atlanta juniors was described by Minick Rushton; observations of the moon and Mars were given by Tim Wyngaard, Madison, Wisconsin; and aurora color slides were shown by two juniors from St. Paul, Minnesota.

During the league business meeting the following were elected officers for the coming year: Chandler H. Holton, Atlanta, president; Norman C. Dalke, Seattle, Washington, vice-president; Ralph K. Dakin, Pittsford, New York, secretary; and Leonard G. Pardue, Miami Springs, Florida, treasurer.

The panel of experts answered questions ranging from amateur societies to auroras. The panel members were Dr. Martha S. Carpenter, Cornell; Kay Gross, Ft. Worth, Texas; Dr. Gartlein; Dr. Shaw; William E. Shawcross, Cambridge, Massachusetts; Armand N. Spitz, Yorklyn, Delaware; Jack Wegener, Barrington, New Jersey; and G. R. Wright, Silver Spring, Maryland. Charles A. Federer, Jr., Cambridge, was the moderator.

At the convention banquet that evening the Astronomical League award was given to Clarence Johnson for his many years of assisting juniors. The main speaker, Mr. Federer, described a trip to Kitt Peak, Arizona (page 493, August issue), and Mount Wilson and Palomar Observatories. A color motion picture on Explorer I was also presented. Door prizes

(Continued on page 560)



President Russell C. Maag, Sedalia, Missouri, opens the first session of the convention. Among those attending were three members of the Association of Lunar and Planetary Observers, from left to right: David Meisel, Fairmont, West Virginia; Ernst Both, Buffalo, New York; and William K. Hartmann, New Kensington, Pennsylvania.

A New Photometer for Very Faint Stars

HAROLD L. JOHNSON, *Lowell Observatory*

FOR the past several years, I have been measuring in globular clusters the colors and magnitudes of individual stars, some of which are very faint. I have been particularly interested in the main-sequence stars in these clusters, for such stars are important to our understanding of the processes of stellar evolution and in the determination of the absolute magnitudes of the cluster-type variables (RR Lyrae stars).

Such a program might normally require the 200-inch telescope, but I have attempted to increase the sensitivity of photoelectric apparatus to the point where stars of the 21st magnitude could be measured with telescopes having apertures of 40 to 82 inches. Accordingly, in April, 1955, I applied to the Research Corporation for funds, and two grants have been made to me. Lowell Observatory also made a considerable financial contribution, and A. J. Gardiner, now with the National Astronomical Observatory, took part in the earlier stages of the development program.

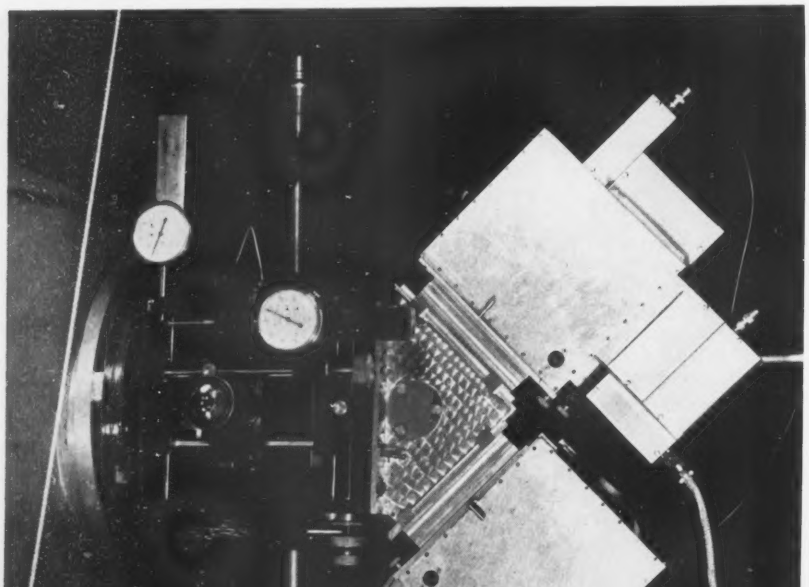
Theoretical computations showed that, contrary to the expectations of some astronomers, the methods of photon counting[1] offer little advantage over the older d.c. methods, regardless of the magnitude of the stars being measured. In view of its greater simplicity, the d.c. method was chosen for the first work. An integrator-type d.c. amplifier was constructed.[2] This consists of a d.c. amplifier of very high sensitivity, followed by an electronic integrator to help with the reading of the deflections, in which the signal-to-noise ratio may be as low as 1/10.

The integrator is, however, purely a convenience, for the same information may be obtained from standard Brown recorder traces by somewhat laborious procedures.[3] Our apparatus was used with the 82-inch reflector of McDonald Observatory for the photometry of stars in the globular cluster Messier 3;[4] the faintest star that was measured photoelectrically had a visual magnitude of 21.9.

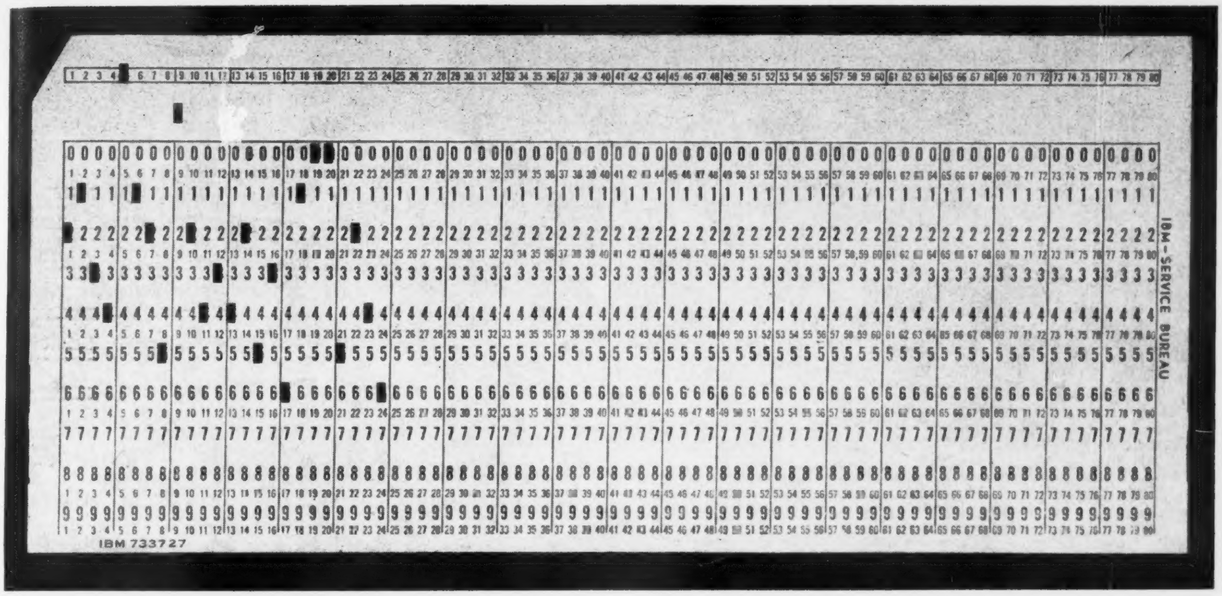
During the course of these observations, faint stars were measured with much less accuracy than would be expected from the number of photoelectrons collected from the sensitive surface of the phototube. Variations in the brightness of the night sky caused the additional uncertainty. The integration period was 117 seconds, with the *star plus sky* and the *sky* alone being measured alternately. But the faintest star measured may contribute only three per cent, or even less, of the total light of star plus sky. If, in the two-minute interval between star and sky measures, the brightness of the sky changed by as little as one per cent, an error of 30 per cent would be introduced in the measured brightness of a faint star.

Because of this result, we started the second part of our program – development of a photometer that measures the sky and star *simultaneously*. This photometer is the principal subject of this article. Its arrangement is shown in the diagram, where light from the telescope enters at the left. A bright star is used for guiding, and it may also be used to locate the observed star by offsetting, since the latter may be so faint as to be invisible in the visual field of view.

After passing through the two nearly identical holes in the diaphragm disk, the light beams are split by the aluminized prism and sent on to the two 1P21 photomultiplier tubes. The tube output in each case passes through a pulse amplifier, a decade counter, and finally to an IBM card-punch machine. The punched cards form a permanent record which may be read and reduced by conventional hand methods, or computed by an IBM calculator. The decade counters may be read and recorded by hand, if desired, as they display the total of each counting period in their banks of flashing lights.



The double-beam photoelectric photometer is mounted at the Cassegrainian focus of the 42-inch Clark reflector at Lowell Observatory, Flagstaff, Arizona. A part of the telescope is seen at the left. Compare this photograph with the diagram opposite. All illustrations with this article are from Lowell Observatory.



Speed and ease of observing are obtained by automatic recording on IBM cards, as in this example.

The picture shows a typical punched card from the photometer. The punched holes are read as follows:

Columns	*Reading*	*Meaning*
1 - 4	2134	Number of the star
5	Minus	Sign of the hour angle
6 - 8	$1^h 25^m$	Hour angle
9	Plus	Sign of the declination
10 - 12	24°.3	Declination
13 - 18	425,361	Total pulse count on 1P21 No. 1 (Star visual magnitude about 11.7)
19 - 24	005,246	Total sky count on 1P21 No. 2

The reader has, no doubt, noticed that pulse-counting techniques are used in this instrument, in spite of the previous comparison with d.c. methods. The explanation is that in the double-beam photometer we are balancing two 1P21's against one another.

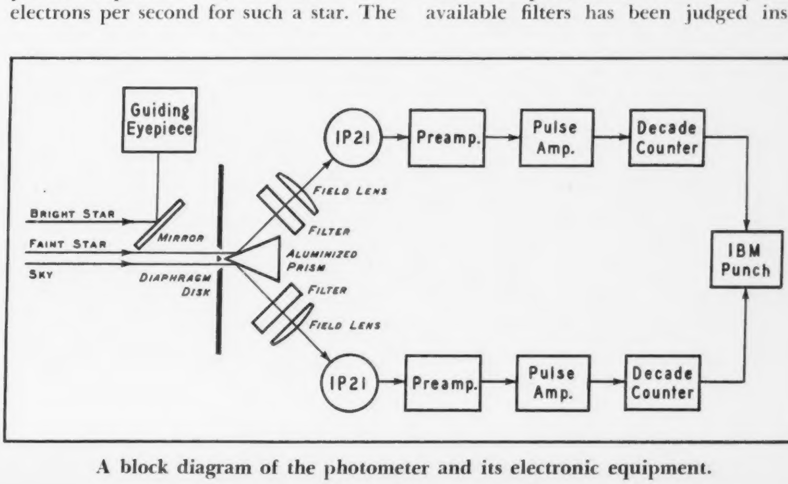
If the amplification of one tube should alter by one per cent, a large error in the measured magnitude of a faint star may result — just as in the case of sky-brightness changes. Such changes are not impossible, and they enter full strength if d.c. methods are used.

However, if we adjust the pulse amplifiers so that virtually all of the pulses from the 1P21's are counted, the resultant count is almost completely independent of small changes in the photomultipliers. The reason is that when all the pulses are counted their total is independent of pulse size. On the other hand, the output of a d.c. amplifier is dependent on both the size and frequency of the pulses.

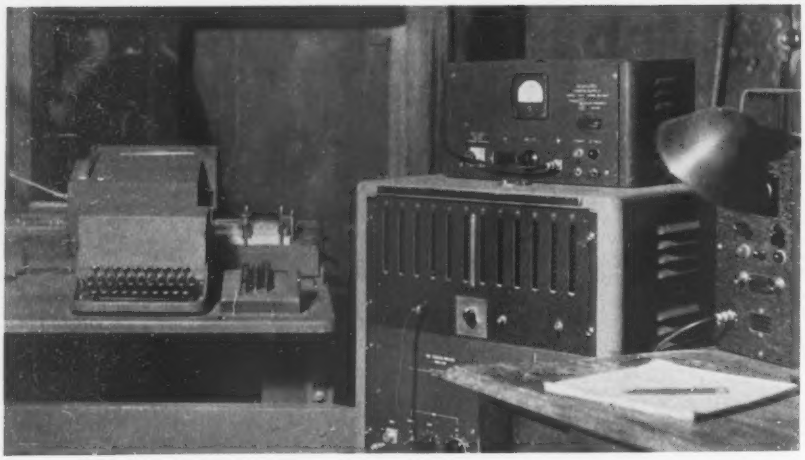
This photometer has been used on the 42-inch reflector at Lowell Observatory to measure stars as faint as visual magnitude 21.6 (photographic magnitude 22.6). The two tubes were selected from 25 new 1P21's bought for the purpose; they are refrigerated with liquid nitrogen to reduce internal noise to a minimum. The cathodes of these two tubes are very nearly the same; the measured output on the 42-inch (yellow filter), reduced to visual magnitude 21.4, is 0.5 electron per second. The ratio of the light-gathering powers of the 200-inch and 42-inch telescopes is 25 to 1, the latter being used with a 40-inch diaphragm. Thus, each of these tubes would produce approximately 12.5 electrons per second on a star of visual magnitude 21.4 observed with the 200-inch. With our two tubes, the total collection would be 25 electrons per second. W. A. Baum[5] gives the output of his EMI photomultiplier at the 200-inch as 3.9 electrons per second for such a star. The double-beam photometer is therefore about 6.5 times as sensitive as Baum's photometer.

This is not the whole story, for we have neglected the effect of variation of the night sky. Computations from actual observations indicate that simultaneous recording of star and sky improves the accuracy by 20 to 100 per cent, depending on the amount of variation of the night sky at the time. This multiplies the weight of an observation by an additional factor of 1.4 to 4. Thus, the over-all sensitivity of the photometer, compared to Baum's published data for his photometer, ranges from nine to 26 times.

The third stage that was planned in the development program was to be the expansion of the new device into a "sextuple-beam" photometer. This would use six photomultipliers, measuring sky and star simultaneously in each of three colors: yellow, blue, and ultraviolet. Dichroic filters would separate the colors, but the improvement in sensitivity using available filters has been judged insuf-



A block diagram of the photometer and its electronic equipment.



The electronic equipment includes the decade counter, in the large cabinet with the rows of lights, and beneath it the pulse amplifiers. On this cabinet and to its right are the high-voltage power supplies for the photomultipliers. The IBM card punch is at the left.

ficient to justify the threefold increase in complexity and expense.

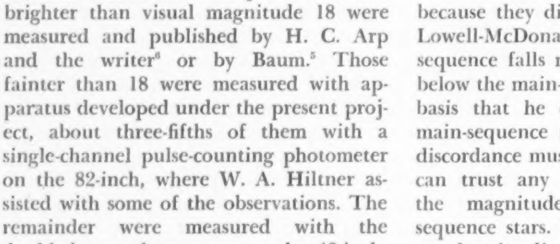
The accompanying color-magnitude diagram for Messier 13 contains photoelectric data obtained with the McDonald 82-inch, the Lowell 42-inch, and the Palomar 200-inch telescopes. The stars brighter than visual magnitude 18 were measured and published by H. C. Arp and the writer[6] or by Baum.[5] Those fainter than 18 were measured with apparatus developed under the present project, about three-fifths of them with a single-channel pulse-counting photometer on the 82-inch, where W. A. Hiltner assisted with some of the observations. The remainder were measured with the double-beam photometer on the 42-inch.

In the diagram a diagonal line represents the "zero-age" main sequence for unevolved stars in the sun's vicinity, fitted to the main-sequence stars of the globular cluster; the assumption is made that the stars in the cluster have the same relation between color and absolute magnitude as do the nearby stars. On this assumption, the distance modulus of M13 (neglecting possible interstellar absorption) comes out 15.1 magnitudes, corresponding to a distance of 10,000 parsecs or 32,500 light-years. (The same result is given by both the 82-inch and the 42-inch observations.) It is noteworthy that the distance modulus deduced from the brightnesses of the cluster variables in M13 is 14.7, assuming that these variables are of absolute magnitude zero; the two moduli differ insignificantly.

Baum's data for the faint stars have been omitted from the M13 diagram because they differ very greatly from the Lowell-McDonald results. Baum's main sequence falls more than one magnitude below the main-sequence line. It is on this basis that he concluded that the M13 main-sequence stars are subdwarfs. This discordance must be cleared up before we can trust any interpretations based on the magnitudes of the M13 main-sequence stars. We hope to find the reason for the discrepancy soon.

REFERENCES

1. W. A. Baum, *Sky and Telescope*, May, 1955, page 264; June, 1955, page 330.
2. A. J. Gardiner and H. L. Johnson, *Review of Scientific Instruments*, New Series, *26*, 1145, 1955.
3. G. E. Kron, *Publications* of the Astronomical Society of the Pacific, *70*, 102, 1958.
4. H. L. Johnson and A. R. Sandage, *Astrophysical Journal*, *124*, 379, 1956.
5. W. A. Baum, *Astronomical Journal*, *59*, 422, 1954.
6. H. C. Arp and H. L. Johnson, *Astrophysical Journal*, *122*, 171, 1955.



A color-magnitude diagram of stars in the globular cluster Messier 13, based on observations by W. A. Baum, H. C. Arp, and the author. Apparent visual magnitude is plotted against the observed blue-yellow color index.

CONVENTION IN ITHACA

(Continued from page 557)

were donated by Armistead and Goodman, Inc.; Criterion Manufacturing Co.; Edmund Scientific Co.; J. W. Fecker, Inc.; Macmillan Co.; Sky Publishing Corp.; United Scientific Co.; and Yale University Press.

At the meeting of the Northeast Region on Sunday morning, the invitation of the Amateur Telescope Makers of Boston was accepted for the region to convene there on October 2, 1959, when a total solar eclipse will be visible in the early morning. In the ALPO session Owen C. Ranck, Milton, Pennsylvania, discussed the Mercury section's work; David Meisel, Fairmont, West Virginia, spoke on the comet section's plans; and Phillip W. Budine, Binghamton, New York, reported on the intensities and colors of Jovian features from October, 1953, to December, 1957.

Plans are now moving rapidly toward the meeting in Denver, Colorado, August 28-31, 1959. This promises to be the most extensive amateur astronomical convention ever held, with the league, the Western Amateur Astronomers, AAVSO, ALPO, and many unaffiliated societies in attendance. Field trips to such institutions as the Air Force Academy, National Bureau of Standards, High Altitude Observatory, and Climax station, are being scheduled.

H. M. C. and W. E. S.

NOVA SAGITTARII 1932

A new star that brightened up temporarily nearly 30 years ago has been found at Maria Mitchell Observatory by Jean Anderson, while comparing photographs of the Milky Way in Sagittarius. The nova is half a minute of arc from the variable star IR Sagittarii she was studying. It was magnitude 15.4 on October 3, 1931, reached its maximum light, 9.1, on April 5, 1932, and then declined slowly in brightness, at a rate of about one magnitude each 100 days.

Miss Anderson examined nearly 1,500 photographs in the Harvard Observatory plate collection without finding any indication of other outbursts of this star between the years 1899 and 1958. Her discovery was a by-product of Dr. Dorrit Hoffleit's systematic study of faint variable stars in an 80-square-degree field in Sagittarius; within this region 10 novae had previously been found.

CORRECTION

On page 512 of the August issue, the final sentence of the second paragraph in the last column should read: "It would have to be raised to the proper height and given the proper *westward* velocity to travel around the earth once in 24 hours." This was pointed out by John A. Church of the University of Virginia, Charlottesville, Va.

The Final Moments of Sputnik II

Luigi G. Jacchia, *Smithsonian Astrophysical Observatory*

As predicted, the end of satellite Sputnik II came on April 14, 1958. It was at 1:55.5 Universal time, over the Atlantic Ocean some 160 miles northeast of Georgetown, British Guiana, in longitude 56°.6 west, latitude 8°.6 north. These facts come from an analysis of many observations on sea and land received by the Smithsonian Astrophysical Observatory, supplemented by information I collected during an investigation under Smithsonian auspices in the Caribbean islands and in the Guianas.

Ten minutes before its final destruction, the satellite had been observed by MOONWATCH teams in the northeastern United States, at Milford, Connecticut; Millbrook, New York; and Bryn Athyn, Pennsylvania. These observations were combined to provide an excellent normal point on the satellite orbit: longitude 74°.00 west, latitude 41°.40 north, height 101 kilometers above sea level, at 1:45:25 UT.

With the assistance of Miss J. R. B. Carmichael, I computed several orbital trajectories by numerical integration, starting from this normal point, and using very different numerical parameters for the atmospheric drag. Of these trajectories, one fitted very well all the reliable quantitative observations from the Caribbean area, and it is plotted on the accompanying map.

This chart shows that the subsatellite path was entirely to the east of the Leeward and Windward Islands; it came within 110 miles of Antigua, 100 miles of Guadeloupe, and 130 miles of Martinique. Barbados had the closest view of the dying satellite, from a distance of only 70 miles.

The estimated error at right angles to the path is about three miles on either side, at latitude 20° north; it is five miles at the closest approach to Barbados, and eight or 10 miles at the end. The terminal point itself may be in error 40 miles or a little more along the direction of motion. Although obtained by computation, this end point is in excellent agreement with the azimuths reported for the disappearance of the object from Trinidad, Georgetown, and two ships at sea. The end point for this satellite is now better known — to this writer at least — than the point in the Soviet Union from which it was launched.

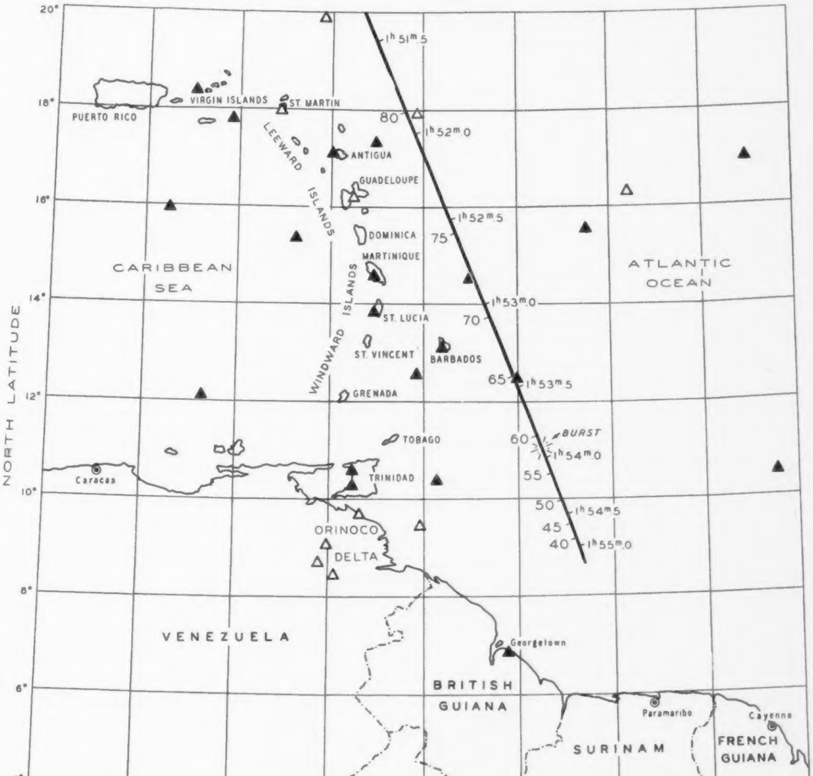
A close look at the map will reveal that the subsatellite path has a slight curvature, especially at the end. This is an effect due to the rotation of the earth under the satellite, while the latter was slowing down.

The last watchers in the United States to see Sputnik II reported it as a glowing object with a faint tail, in which tiny luminous particles were discernible through binoculars. Its brightness was estimated between magnitude +1 and +3, according to the distance from the observer. These facts are from reports by R. E. Jenkins, Pittsford, New York, and R. D. House, Merrow, Connecticut, as well as the three MOONWATCH stations already mentioned. If the data are reduced to a standard distance of 100 kilometers, the magnitude of the object comes out +1, and the length of the tail one degree, when seen perpendicularly. The tail was therefore about one mile in length. Mr. House reported a five-degree tail through binoculars, but invisible to the naked eye.

After crossing Long Island southward, the satellite went unreported for five minutes. When next seen, by ships in the Caribbean, it was in latitude 23° north and had become a spectacular sight. The tail was 40 miles long when seen from Antigua (latitude 17° north), 50 miles long at the latitude of Martinique (14°.5 north), 60 miles long off Barbados (13° north), and about 70 miles long on crossing latitude 10°, when it could be seen from Trinidad, some 300 miles away.

The rocket itself appeared as a dazzlingly bright star, white with tinges of green or blue. The master of the British tanker *Regent Hawk,* at the time southwest of Barbados and 160 miles from the satellite's path, reports that it appeared three or four times brighter than Venus at its brightest. This would make the "absolute magnitude" (here defined as seen from 100 kilometers) about −8. According to all eyewitnesses, the tail was a few magnitudes brighter than the head, so the total absolute magnitude of the cometlike object was roughly −10.

As seen from Barbados, at closest range, the main body was followed by a flamelike tail about 20 degrees long. Bright globules trailed behind, each with its own tail like a miniature replica of the whole object. Dozens of these globules were visible at any time. They trailed as much as 40 degrees behind the head, falling below it before they were extinguished. Some of the globules split and resplit, always forming new cometlike objects. The color of the flame was yellowish-white near the head, gradually turning to orange



This chart by the author is labeled in Universal time and height in kilometers. Filled triangles are quantitative reports, open ones qualitative.

toward the end of the tail. There seemed to be small, semiregular fluctuations in brightness, with a period of the order of three seconds.

This was the general aspect during all the flight in the Caribbean area down to latitude 11° north, except that from the more distant observation points the globules could not always be seen. But then there was a burst — witnessed from Trinidad — and Sputnik II seemed to dissolve into an elongated shower of fragments. These slowly died out, leaving only one piece — the leader of the procession — to continue on its path for another half minute or so, trailing a little tail, until it also faded out. The end of the phenomenon was observed at relatively close range from British Guiana, where the last fragment died out while still 10 degrees above the horizon. It was also seen from Trinidad, much farther away, very close to the horizon, as well as from the German ship *K. G. Lohse* and the Argentine vessel *Rio Atuel*. All these reports show that the object was fading quite rapidly before it reached the horizon.

It is clear from this synoptic description of events that the surface of the rocket was melting all the time. The globules must have been drops of molten metal, as indicated by their repeated splitting. It appears that the melting process had already started when the satellite was last seen in the United States. During the burst at latitude 11° north, the thinned-out rocket probably disintegrated into a great many small fragments.

Some of these may have vaporized in mid-air, while others may have slowed down until their velocities became too low to sustain the light-producing mechanism, so they fell unseen into the sea. This probably was the fate of the last remaining fragment, which may have been a very sizable part of the rocket.

The steepness of the angle of descent and the low altitude of the burst preclude any possibility that some fragments may have continued their flight much beyond the end of the path as plotted on the map. It is my firm conviction that no part could have reached the Guiana coast.

To collect eyewitness reports, I visited Trinidad, British Guiana, Surinam, Barbados, Martinique, and Antigua. My task was made much easier by the American consular authorities, who gave advance publicity to my arrival at various places and provided a locale for interviews.

In Trinidad, my first witness was the American consul general, W. W. Orebaugh, who had seen the fiery descent of Sputnik II from a boat, while on a fishing trip. Other Trinidad eyewitnesses included the local commissioner of prisons, D. St. Aubyn, and the commissioner of police, E. H. F. Beadon. The latter could not come himself, so he dispatched a police car to hunt me down, and I was duly spotted and stopped on a street in Port of Spain in the act of taking a photograph. My understandable apprehension was relieved only when I opened the official document for which I had to sign a receipt; it was a detailed description with a map and a colored drawing of the celestial corpus delicti.

In Barbados I had invaluable help from the Barbados Astronomical Society, which greatly reduced my work by assembling the eyewitnesses among its members for a collective interview at the house of its dynamic director, Dr. Harry Bayley. (On my return to Cambridge, I received a letter from Mrs. Bayley telling that her husband had suddenly died of a heart attack less than two weeks after I had enjoyed his hospitality.)

So spectacular was the phenomenon in Barbados that almost half the population saw it. A near-stampede started in a movie theater (an open-sided structure with a roof on columns) when the audience spotted the fiery satellite.

No reports had come to the Smithsonian from Paramaribo, in Surinam, although its location would have afforded a view of the end of the satellite. The reason, it turned out, was rainy weather along the Surinam coast that night. Every effort was made to ferret out possible eyewitnesses in locally clear areas; announcements were made through the press, radio, and even motion-picture theaters; a conference was called at the U. S. consul's home to which all the local notables came, but to no avail.

All of the usual hazards of the astronomical investigator were present during the trip — persons who just wanted to tell about their private cosmologies, others who wanted money for their reports, and also false witnesses. The main difficulty — encountered by every astronomer who has tried to collect reports of bright fireballs — was interpreting eyewitness statements about height above the horizon. The concept of angular elevation is alien to the layman; he ordinarily gives an estimate in terms of feet and is usually off by a factor of 100 or so. Even when the estimated height is given in degrees, checking proves it to be too large, often by a factor of two. An altitude of 20 to 30 degrees is almost invariably judged to be 45 degrees, even by highly educated people. A good policy in such cases is to conduct the interview at night, and let the witness point out stars that are at the height at which the object was seen. The angular altitudes of landmarks used in daytime interviews can later be checked by the star test, too.

OBSERVING THE SATELLITES

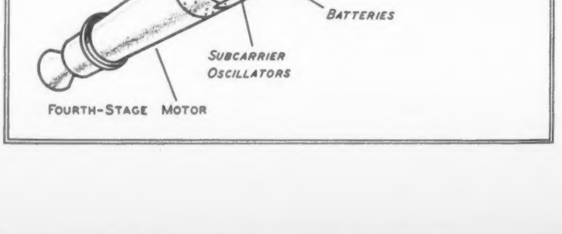
Another American Satellite

THE northeasterly course of Explorer IV on its July 26th launching from Cape Canaveral sent a United States satellite farther north and south than any of its four predecessors. This change has the important scientific result that American satellite observations of cosmic ray intensity can be made over a range of latitudes much greater than hitherto possible.

Previous launchings toward the southeast had carried Explorers I and III and Vanguard I into orbits confined within latitudes 35° north and 35° south. Downrange safety requirements make it impossible to launch from our east coast a booster rocket with an inclination much larger than the 50 degrees of Explorer IV. At this angle to the earth's equatorial plane, the new satellite is sweeping about three-quarters of the earth's surface. The three Soviet Sputniks were launched from a more northerly site, and have covered the globe between the 65° parallels.

Explorer IV was placed in orbit by a Jupiter C rocket, virtually identical with that of Explorer III except for a more efficient solid propellant for the upper stages. This rocket system is based on the U. S. Army's operational Redstone, a 200-mile surface-to-surface missile developed from the German V-2. Atop this 60-foot liquid-fuel stage, the Jupiter C has two concentric clusters of solid-fuel rockets, which are scaled-down versions of the 100-mile Sergeants.

The outer ring of 11 rockets forms the second stage, and the inner circle of five rockets provides third-stage power. The



Like the earlier satellites launched by the U. S. Army, the latest Explorer is a rocket casing and nose cone. As this cutaway drawing shows, the principal parts are fabricated to fit the restricted dimensions of the rocket's interior.

satellite itself is built into a Sergeant, the fourth stage. Eight minutes before launching, an electric motor began to spin the entire upper assembly at about 750 revolutions per minute, in order to impart stability to the later stages after they separated.

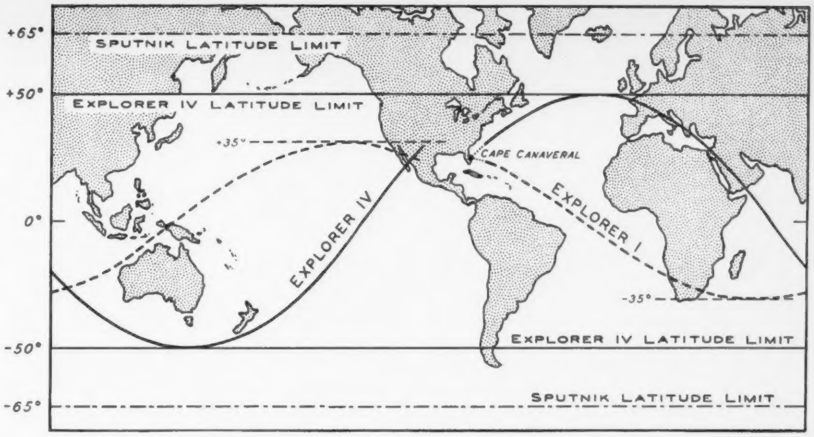
The initial orbital period of Explorer IV — known to astronomers as 1958ϵ — was 110.2 minutes, found by Vanguard Computing Center from early radio observations. While this is the shortest initial period of an American satellite, it is longer than that achieved by any of the Russian launchings. From the perigee height of 163 miles and the mass-area ratio, we can estimate the expected lifetime as on the order of two years.

The instrument package of Explorer IV and its fourth stage are orbiting as a unit, forming a satellite of the size and shape of Explorers I and III, but more than seven pounds heavier. Some of the facts listed in the accompanying table may be compared with the corresponding data for earlier satellites, tabulated on page 459 of the July issue.

SATELLITE	
Name	Explorer IV
Launching date	July 26
Launching time (UT)	15:00
DESCRIPTION	
Shape	Cylinder
Length (inches)	80
Diameter (inches)	6
Weight (pounds)	38.43
Payload weight (pounds)	18.26
INITIAL ORBIT	
Inclination (degrees)	50.13
Anomalistic period (minutes)	110.208
Perigee (miles above earth)	163
Apogee (miles above earth)	1,373

Instruments

EXPLORER IV is instrumented specifically to measure the intense radiation encountered by Explorers I and III at heights around 1,000 miles, as told on page 398 of the June issue. On the two earlier flights, at such altitudes cosmic ray counters showed unexpectedly high levels of unidentified radiation — sufficient to jam the Geiger tubes. One possibility, as yet unconfirmed, is that fast-moving electrons from the sun had generated X-rays on striking the satellite's skin. Because intense X-rays are very dangerous to man, the further measurements by 1958ϵ will have important implications for manned spaceflight.



The paths of Explorers I and IV are plotted for their initial circuits of the world, to show the wider latitude range of the newest American satellite.

The entire payload in Explorer IV is devoted to cosmic ray observations. Inside the steel casing of the satellite are two Geiger tubes, one shielded with 1/16 inch of lead. Mounted outside are two scintillation counters — cesium iodide crystals cemented to photomultiplier tubes. One of these units measures the total intensity, the other the frequency of cosmic ray impulses.

Data obtained from these four sensing devices are telemetered immediately to ground, for reception by a chain of 26 stations around the world. The satellite does not use a tape recorder, presumably because the network of stations is now broad enough to insure practically continuous monitoring. The two radios in the satellite transmit on 108.00 and 108.03 megacycles, at powers of 10 and 30 milliwatts, respectively.

Unlike earlier United States moonlets, Explorer IV does not transmit temperature data. It had already been learned from 1958α that a suitable pattern of sunshine absorbing and reflecting areas on the surface would keep the internal temperature within limits allowing successful operation of electronic equipment.

July's Explorer was the first American satellite to be launched under the direction of the Advanced Research Project Agency of the Department of Defense, in co-operation with the Army.

Satellite Brightnesses

A 2-INCH telescope is large enough to show every one of the artificial satellites now in orbit, under the most favorable conditions. This rather surprising conclusion follows from quite simple calculations.

The table at the lower left shows visual magnitudes for current satellites, as seen by observers directly underneath them, at times of perigee and apogee. In each case two extreme magnitudes are cited, when the satellite is fully broadside to the observer (maximum aspect), and end on (minimum aspect).

These magnitudes are based on the assumption that the relative positions of sun, satellite, and observer are the most favorable possible, and that the satellite surface is mirror-smooth, reflecting half the light falling on it. In the calculations, I have used the estimated heights as of August 1st; they will not have changed enough by September to alter the magnitudes significantly. The most rapid change is for the apogee of 1958δ1, which was expected to be about 70 miles lower by the end of August, but this makes the object only about 0.2 magnitude brighter at apogee. For satellite distances other than those in the table, add to the magnitude five times the logarithm of the ratio of the actual distance to the tabulated distance.

At the bottom of the table are listed the minimum telescope apertures needed to observe the objects for maximum aspect at perigee height, and for minimum aspect at apogee height.

MARSHALL MELIN
Research Station for Satellite Observation
Harvard Observatory
Cambridge 38, Mass.

Calculated Characteristics of Current Satellites

SATELLITE	*1958α*	*1958β1*	*1958β2*	*1958δ1*	*1958δ2*	*1958ϵ*
PERIGEE						
Height (miles)	219	408	408	120	133	163
Magnitude, broadside	5.6	6.2	10.0	−1.5	2.1	5.1
Magnitude, end on	8.7	7.7	10.0	5.5	2.3	8.2
APOGEE						
Height (miles)	1,510	2,460	2,460	1,000	1,100	1,365
Magnitude, broadside	9.8	10.1	13.9	3.6	6.7	9.6
Magnitude, end on	12.9	11.6	13.9	10.6	6.9	12.7
MINIMUM TELESCOPE APERTURE (inches)						
Brightest situation	*	0.3	1.6	*	*	*
Faintest situation	6.0	3.3	9.6	2.1	0.4	5.5

*Naked eye.

The heights are valid for August 1, 1958; those for 1958β1 are estimated, as that object is lost. Since the size of 1958δ1 is unknown, the magnitudes for it are based on observations of brightness.

Getting Acquainted with Astronomy

Things To Observe in the Sky — IV, *by Edward G. Oravec*

Minor Planets

Of the thousands of asteroids or minor planets that inhabit the general region between the orbits of Mars and Jupiter, several dozen become as bright as the 8th or 9th magnitude at opposition and may then be located with a telescope. Their paths are predicted in advance, and ephemerides for the brightest of them appear regularly in *Sky and Telescope*. Several of the asteroids may be seen with binoculars, but only one, Vesta, attains the 6th magnitude and under excellent conditions may be detected with the naked eye.

Comets

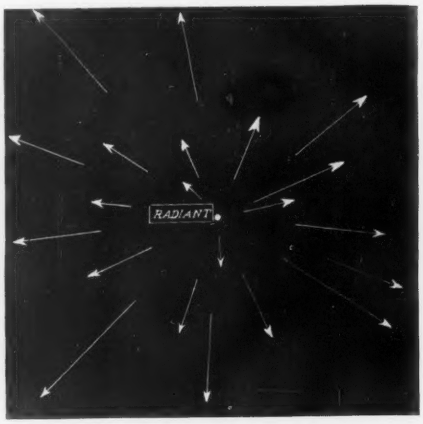
The appearance of a bright comet always evokes great interest on the part of amateurs and laymen, but such events are rare. Comets within the range of small instruments, however, and some that attain naked-eye visibility, may appear on the average every year or two. As soon as the predicted path of any comet is published, it should be plotted in a star atlas to enable the observer to follow the object as it passes from one constellation to another. It may remain visible in amateur instruments over a period of several weeks or months.

The brightness of a comet cannot be accurately predicted, because daily and sometimes hourly variations occur. Features to look for in any comet are the coma (head) and the nucleus; also note the appearance, length, and direction of the tail, if one exists. The tail is generally much fainter than the head and is sometimes rather difficult to detect.

A few amateur astronomers have enviable reputations as the discoverers of comets. This they achieve by long years of regular painstaking search of the sky, at every opportunity, with telescopes of wide field and great maneuverability. Charles Messier drew up his catalogue of nebulous objects to aid him in comet seeking. A comet is identified by its usually fuzzy appearance and its change of position against the background of stars – such motion may be detected in a few hours or from night to night.

Meteors

Small bits of matter, plunging through the earth's atmosphere, glow briefly and are called popularly "shooting stars." In general, these meteors are of two kinds, those that travel in swarms around the sun and are seen as meteor showers near the same date each year, and sporadic ones, which do not belong to showers. The brightest meteors are called fireballs,



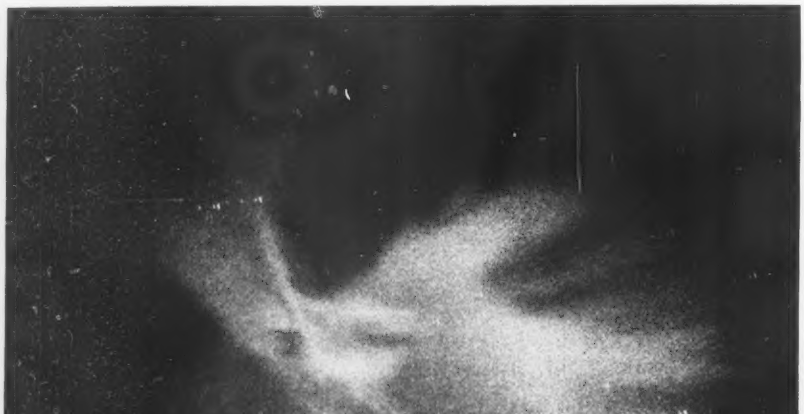
Perspective makes shower meteors seem to radiate from a point on the sky.

and some of these, exploding as they fall, are bolides. Occasionally they drop meteoritic fragments to the earth. To retrace the path of a fireball and predict where it may have landed requires reports from observers over a wide area. If such reports, by amateur astronomers and laymen alike, lead to the finding of meteorites, a significant contribution to the study of meteoritics has been made.

Visual observing by amateurs in the past has given us much information concerning both shower and sporadic meteors, but recently high-speed cameras and the application of radar techniques have overshadowed the earlier visual methods. Nevertheless, amateurs are occasionally called upon to assist with specific professional programs, and the recording of a meteor shower is one of the best projects for group observing by members of an astronomy club. The finest annual showers include the Perseids in August and the Geminids in December.

The Aurora

A display of the aurora borealis or northern lights is always worth watching. It is most apt to be observed when sunspots are numerous, and at such times the aurora may be seen in the northern and middle latitudes of the United States, sometimes even in Florida. A single display generally follows a definite sequence of changing arcs, rays, and draperies, and auroral observers record the times at which these changes occur. Sometimes an aurora has features that are colored green and red, adding to the beauty of the spectacle. The aurora lends itself, therefore, to color photography, and some amateur groups, notably the Milwaukee Astronomical Society, have built special cameras for auroral work. Dr. C. W. Gartlein, Cornell University, Ithaca, N. Y., wishes to recruit other serious amateurs in his aurora observing program.



Theodore L. Agos took this picture of a coronal aurora at Bristol, New Hampshire, very early on the morning of June 29th. **(See page 580.)**

ZODIACAL LIGHT AND GEGENSCHEIN

Most easily seen in the tropics but often observed in mid-northern latitudes, the zodiacal light is a tapered glowing band extending along the ecliptic from the sun's position and seen after twilight or before dawn. The most favorable times to look for it in the Northern Hemisphere are evening in the spring and morning in the autumn, for at these seasons the ecliptic is at its greatest angle with the horizon. To observe the zodiacal light, one should have his eyes adapted to the dark and should be away from artificial lights. The zodiacal light is believed to be caused by sunlight reflected from fine dust in the solar system between the earth and the sun.

The gegenschein, or counterglow, is very elusive. It is situated opposite to the sun (180 degrees from it on the ecliptic), and is seen only under the most favorable conditions. It appears as a very faint patch of light, roughly circular, some eight or more degrees in diameter. Late September and October are good times to try finding it, for then the counterglow is in the faint regions of Pisces and Cetus. It is probably caused by the reflection of sunlight from interplanetary dust. The visibility of both of these phenomena was discussed by Franklin E. Roach and Pauline M. Jamnick in "The Sky and Eye," *Sky and Telescope*, February, 1958, page 164.

While a member of the Hayden Planetarium's eclipse expedition to the Peruvian Andes in June, 1937, the famous astronomical painter, D. Owen Stephens, did several color canvases of the southern sky. From a height of 14,600 feet he depicted here the striking appearance of the zodiacal light in the tropics. Courtesy, American Museum of Natural History.

Astronomical Puzzle

ACROSS

1 Circumpolar constellation.
11 Negative.
12 Peacock.
13 Missile.
14 Pole star of 2750 B.C.
17 Adverb.
18 Star in Orion's belt.
22 Bird.
23 Horned animal.
24 Toward heaven.
26 Nearest star.
29 Abbreviation for amount.
31 ——— star.
32 Snake.
36 Conjunction.
38 River of southern Brazil.
40 German discoverer of asteroids (1863-1932).
42 Contains Small Magellanic Cloud.
43 Greek letter.
44 American radio astronomer.
46 Never in U. S. skies when Scorpius is.
47 Big or Little ———.
48 Zodiacal constellation.

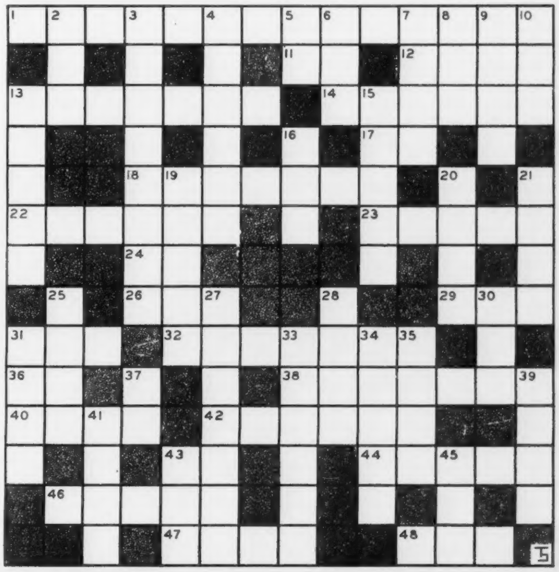
DOWN

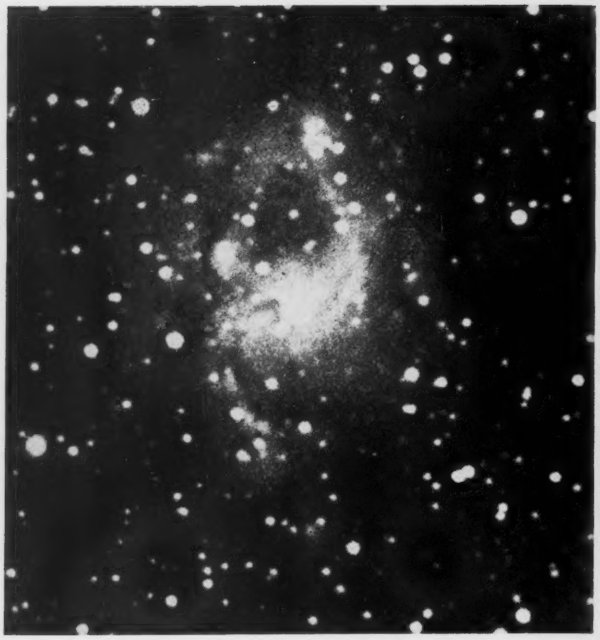
2 Sacrificial stand.
3 Never runs uphill
4 South circumpolar constellation.
5 Article.
6 Decompose.
7 Bird of paradise.
8 Scientist's workplace.
9 Man's name.
10 Father's relative.
13 1st-magnitude star.
15 Star in Aries.
16 Musca.
19 Hunts in packs.
20 Famous variable.
21 Contraction.
25 Constellation between Achernar and Canopus: abbrev.
27 Planet.
28 Sometime pole star.
30 Married woman.
31 Direction.
33 Painter.
34 Star in Sagittarius.
35 River in France and Germany.
37 Preposition.
39 ——— Major or Minor.
41 Constellation of the Ring nebula.
43 Cribbage term.
45 Asteroid 111.

MOSTLY CONSTELLATIONS AND STARS

This crossword puzzle was submitted by Terry Schmidt, 668 Jefferson Ave., Elgin, Ill., who took about six hours to devise it.

(The solution is on page 569 of this issue.)





The galaxy NGC 6221, photographed with the 74-inch reflector of Radcliffe Observatory, Pretoria, South Africa. The blue-light picture at the left was taken without a filter on an Eastman 103a-O plate, exposed for one hour on August 4, 1954. At the right is a 90-minute exposure in red light, secured with a 103a-E plate behind an Ilford 205 filter, on July 5, 1956. Both reproductions have a scale of about 2.2 seconds of arc per millimeter. Because NGC 6221 is observed through our own Milky Way (note the rich star field), its blue-light image is greatly dimmed by interstellar dust. Red light penetrates the dust much better, and shows that this object is definitely a galaxy.

Among Southern Galaxies—VIII

COMPARED with the other galaxy photographs in this series, the two of NGC 6221 at the top of this page are exceptional for the richness of foreground stars. This field is only 11 degrees from the central line of the Milky Way, and very few galaxies can be seen through the interstellar dust at such low galactic latitudes.

NGC 6221 is dim in the blue-light view, taken without a filter, at the left, but the red-light photograph at the right shows clearly that it is a barred spiral. For many years the true nature of this object was in doubt; the *New General Catalogue* of 1888 even called it a globular star cluster!

This SBc-type system is located in the far southern constellation Ara, at right ascension $16^h\ 48^m.5$, declination $-59°\ 08'$ (1950 co-ordinates), in the same finder field of view as the 4th-magnitude star Eta Arae. It is plotted in the Skalnate Pleso *Atlas of the Heavens*.

G. de Vaucouleurs, in his list of 20 bright southern galaxies on page 525 of the September, 1957, *Sky and Telescope,* gives the total photographic magnitude of NGC 6221 as about 9.6, and its size as three by two minutes of arc. Its radial velocity is unknown.

On the facing page is NGC 1808, a spiral system of unusual form, in a region showing many faint nebulae. It is in Columba, at right ascension $5^h\ 05^m.9$, declination $-37°\ 34'$ (1950). Because this galaxy is 35 degrees from the central line of the Milky Way, the foreground stars are much more thinly scattered than in the field of NGC 6221 discussed before.

The total brightness of NGC 1808 matches that of a star of photographic magnitude 10.8, making this galaxy fairly conspicuous in amateur telescopes. Its visual appearance in an 18-inch reflector was described by Sir John Herschel, at the Cape of Good Hope: "December 26, 1835. Bright; elongated; 3′ long, 90″ broad; in a field strongly illuminated by the moon in her first quarter."

Photography, however, brings out much internal detail in this interesting system. Dr. de Vaucouleurs finds that NGC 1808 is at the transition stage between types S0 and Sa, with characteristics of both ordinary and barred spirals. He classifies the object as (R)SAB(s)0/a, according to the system explained on page 582 of the October, 1957, issue.

The reproduction shows the galaxy's bright central lens or bar, with a small nucleus and complex pattern of dark lanes, which are stronger on the near side. Long exposures of this system disclose a very faint outer ring or loop formed by weak, smooth arms; these greatly increase the over-all dimensions, to 7.0 by 4.7 minutes of arc.

If NGC 1808 were seen exactly edgewise, it might look much like Messier 82, usually classified as irregular, but completely unrelated to the Magellanic type of galaxy. The radial velocity of NGC 1808 is unknown, but Dr. de Vaucouleurs estimates its distance as roughly 20 million light-years.

FACING PICTURE: The great stellar system NGC 1808 in Columba, photographed on October 8, 1953, with the 74-inch Radcliffe telescope. For this one-hour exposure in blue light, an Eastman 103a-O plate was used without a filter. Although some bright knots are recognizable, the rather ill-defined arms are not resolved into stars. A conspicuous feature is the complex pattern of dark lanes, those on the eastern side showing a radial arrangement.

These three pictures continue the series begun in February, 1958, of selections from the Cape Photographic Atlas of Southern Galaxies. They are being reproduced by permission of R. H. Stoy, director of the Royal Cape Observatory, Cape of Good Hope, South Africa.

Amateur Astronomers

AMATEURS IN HOLLAND

The Haarlem Weather and Astronomy Club was founded on April 1, 1933, as a subdivision of the Netherlands Weather and Astronomy Association. Its 25th anniversary was celebrated last spring by our more than 100 members.

In addition to attending lectures on astronomy and meteorology, we take trips to the observatories at Leiden and Utrecht, the Hague planetarium, radio telescope installations in our country, and weather stations at the Royal Netherlands Meteorological Institute in Bilt and at the Schiphol Airport in Amsterdam.

Within our club there are special working groups for observing the weather, occultations of stars by the moon, and meteors. There is also a telescope making section.

We will be pleased to hear from other amateur societies.

E. A. VAN DER ELST
St. Josephlaan 15
Amstelveen, Netherlands

NORTH CENTRAL REGION

Larry Easton, Fox River Valley Astronomical Society, Oshkosh, Wisconsin, was elected vice-chairman of the North Central Region of the Astronomical League at its convention last May in Milwaukee (page 453, July issue). He succeeded Richard R. Fink of Milwaukee.

MASSILLON, OHIO

The Massillon Astronomy Club has 27 regular members. Further information may be had from Raymond L. Snavely, Rte. 1, Barrs Rd., Massillon, Ohio.

PALMER, MASSACHUSETTS

The Pioneer Valley Astronomy Club, founded last November, now has 34 regular members. Monthly meetings are held on the third Tuesday at 8 p.m. in the Three Rivers grammar school.

Officers are Edward Reynolds, president; Kenneth W. Manning, vice-president; and Richard E. Cavanaugh, secretary-treasurer, 14 Lathrop St., Palmer, Mass.

THIS MONTH'S MEETINGS

Cambridge, Mass.: Amateur Telescope Makers of Boston, 8 p.m., Harvard Observatory. Charles A. Federer, Jr., "Kitt Peak Observatory."

Edinburg, Tex.: Magic Valley Astronomical Society, 8 p.m., Pan American College science building. Sept. 26, Paul R. Engle, "Structure of the Visible Universe."

San Antonio, Tex.: San Antonio Astronomy Club, 7:45 p.m., Witte Museum. Sept. 26, F. H. Hagner, "How To Locate Stars."

Washington, D. C.: National Capital Astronomers, 8:15 p.m., Commerce Department auditorium. Sept. 6, Dr. James E. Kupperian, Naval Research Laboratory, "Rocket Astronomy."

JUNIORS IN CALIFORNIA

Three new junior clubs have been formed in California: The Oxnard Astronomical Society may be contacted by writing James Bukowski, 3111 S. E St., Oxnard; the Sunland Astronomical Association, Douglas Carrie, 9627 Wheatland Ave., Sunland; and the Sunnybrae Amateur Astronomers Club, Edmund Hedemann, 905 Haddon Dr., San Mateo.

NASHUA, NEW HAMPSHIRE

A group of 10 amateurs have formed the Merrimack Valley Astronomical Society. The secretary is Arthur J. Barrett, R.F.D. 2, Reeds Ferry, N. H.

MIDLAND, TEXAS

Eleven juniors and two adult members comprise the Midland Amateur Astronomical Society. Interested persons should communicate with Mary Ann Price, 2106 W. Michigan, Midland, Tex.

HUNTING MESSIER OBJECTS

With the beginning of the International Geophysical Year in July, 1957, a friend and I, both 15 years of age, started a Messier race — a search for all of Charles Messier's famous objects — our time limit being the end of the IGY.

From mid-September, 1957, to the last day of school this past June, I recorded only seven of the hundred Messier objects, since my school work took precedence over my observing. But by June 20th I had succeeded in seeing an additional 63, even though my home is close to the bright lights of Camden and Philadelphia.

My equipment is quite modest — a $4\frac{1}{4}$-inch reflector, Olcott's *Field Book of the Skies*, and Norton's *Star Atlas*. I would like to hear from other amateurs who may have conducted such a project.

FRANCIS LODGE
117 Fern Ave.
Collingswood, N. J.

Thomas R. Bosma's observatory in Iowa.

TWO AMATEUR OBSERVATORIES

THE two homemade observatories illustrated here were designed to solve problems that confront many amateurs. At Buffalo Center, Iowa, Thomas R. Bosma last year constructed an 18-foot-high well-insulated building to withstand the cold prairie winters. It houses his 4-inch refractor, and has an extension used for an office and library. Currently Mr. Bosma is an active observer of northern lights, sending his reports to the IGY aurora center at Cornell University.

At Seguin, Texas, Sonny Dietz wanted an unobstructed horizon for his 3-inch refractor, and decided to mount it on a tower above treetop level. Originally a two-man canvas duckblind, the dome was treated with aluminum paint to combat heat. The 20-foot structure is braced by cross cables, and Mr. Dietz has observed in winds up to 30 miles per hour without serious vibration. The installation cost less than $200, taking about six months to complete.

Sonny Dietz built this 20-foot tower to view the sky down to the horizon.

Summertime is star-party time for California's Eastbay Astronomical Society, as for many other amateur groups. This front-cover picture from its bulletin shows unusual co-operation by the heavenly bodies.

FOUCAULT PENDULUMS

The most dramatic proof of the earth's rotation is a simple experiment first performed in 1851 by the French physicist Leon Foucault. Suspending a heavy weight from a 200-foot wire, he was able to demonstrate that the plane in which this pendulum kept swinging remained independent of the turning of the earth beneath it.

In the Amateur Scientist department of the June, 1958, *Scientific American,* the operation of Foucault pendulums is explained, and ways are described of overcoming mounting problems and of supplying power to keep up the motion. With little cash outlay, anyone handy with tools can make a compact Foucault pendulum for himself.

Foucault was the scientist who devised the knife-edge method for testing mirrors, and he was an independent inventor of silvered glass mirrors for telescopes.

(Solution to the puzzle on page 565)

C	A	M	E	L	O	P	A	R	D	A	L	I	S
	R		R		C		N	O		P	A	V	O
S	A	G	I	T	T	A		T	H	U	B	A	N
P			D		A		F		A	S		N	
I			A	L	N	I	L	A	M		M		I
C	Y	G	N	U	S		Y		A	R	I	E	S
A			U	P					L		R		N
	H		S	U	N			V			A	M	T
D	O	G		S	E	R	P	E	N	S		R	
O	R		O		P		I	G	U	A	S	S	U
W	O	L	F		T	U	C	A	N	A			R
N		Y		N	U		T		K	R	A	U	S
	O	R	I	O	N		O		I		T		A
		A		B	E	A	R			L	E	O	

SOUTHWEST CONVENTION

There were 62 members and guests at the Southwest regional meeting of the Astronomical League, held at the Kilgore, Texas, Junior College on May 30-31. The East Texas Astronomical Society was the host.

The principal address was given by Walter H. Haas, Las Cruces, New Mexico, on amateur observations of the rotation of planets. A highlight of the Ft. Worth juniors' program was a talk by 10-year-old Jean Walker on the clock-and-fist method for locating stars.

E. M. BREWER
5218 Morningside Ave.
Dallas 6, Tex.

HERE AND THERE WITH AMATEURS

Most of these societies hold regular meetings once or twice monthly, at which interested persons are always welcome. Details of each society's program can be obtained from the official whose name and address are given here.

*Members receive *Sky and Telescope* as a privilege of membership.
†Member organization of the Astronomical League.
‡Member organization of the Western Amateur Astronomers.
°Society has junior section.
‖Independent junior society.

ALABAMA

BIRMINGHAM
Shades Valley Astronomy Club *
Mrs. I. M. Cox, 208 Dexter Ave. (9). TR 1-1639

FLORENCE
Tri-Cities Astronomy Club *
R. May, 606 River Bluff Dr., Sheffield. EV 3-7845

HUNTSVILLE
Rocket City Astronomical Ass'n. *†
G. A. Ferrell, 621 Franklin St. JE 4-4809

ARIZONA

PHOENIX
Phoenix Observatory Ass'n. *‡
A. H. Hoff, Phoenix College. AM 6-4441

TUCSON
Tucson Amateur Astronomers *†‡
D. Strittmatter, 1840 E. Lee St. EA 5-9453

ARKANSAS

AUGUSTA
Augusta Astronomy Club *†‖
J. W. Haralson, Box 634. Augusta 35

LITTLE ROCK
Arkansas Amateur Astronomy Club *†
C. P. Kulp, 1322 Donaghey Bldg.

CALIFORNIA

BAKERSFIELD
Kern Astronomical Society, Inc.
R. Stephens, 1230 Washington Ave., Oildale. EX 9-6587

EUREKA
Astronomers of Humboldt
W. N. Abbay, Jr., 1745 Margaret Lane, Arcata. VA 2-4403

FRESNO
Central Valley Astronomers *‡
G. Reavis, 626 W. Lamona. AM 4-9771

LAGUNA BEACH
Laguna Beach Astronomy Club
Miss E. Phillips, 370 Anita St.

LONG BEACH
Excelsior Telescope Club *†‡
T. R. Cave, Jr., 265 Roswell Ave. HE 4-2263

LOS ANGELES
Los Angeles Astronomical Society, Inc. ‡
Miss L. Carlson, 3047 Vista St., Long Beach.

OAKLAND
Eastbay Astronomical Society, Inc. *‡
Miss P. Metz, 4827 Brookdale Ave. (19). KE 6-2074

OROVILLE
Feather River Astronomy Club
J. T. Jensen, Rte. 4, Box 1732. LE 3-0471

PALO ALTO
Peninsula Astronomical Society *‡
Miss A. Alksne, 4115 Amaranta Ave. DA 2-4406

PASADENA
Ass'n. of Amateur Astronomers ‡
E. Sloman, 1100 Armada Dr.

PLEASANT HILL
Mount Diablo Astronomical Society
D. F. Charles, 868 Audrey Court.

RED BLUFF
Mt. Lassen Amateurs
F. Wyburn, Box 502.

REDLANDS
Redlands Astronomical Society *
Mrs. E. Patterson, 2698 Fremontia Dr., San Bernardino. 83-7238

RIVERSIDE
Riverside Astronomical Club
B. F. Jones, 5551 Magnolia Ave. OV 3-1854

SACRAMENTO
Sacramento Valley Astronomical Society *‡
Mrs. H. Smith, 1608 48th St. (19). GL 1-1483

SAN FRANCISCO
San Francisco Amateur Astronomers *‡
H. Sturiale, 1349 Clayton St. UN 3-3808

SAN JOSE
San Jose Amateur Astronomers *‡
W. W. Phelps, 21090 Hazelbrook Dr., Cupertino. CH 3-1649

SAN RAFAEL
Marin Astronomical Society *‡
J. P. Treleven, Box 102, Fairfax.

SANTA ANA
Orange County Amateur Astronomers *
D. Miller, 12601 Glen St., Garden Grove.

SANTA BARBARA
Santa Barbara Star Cluster ‡
Capt. C. Adair, 607 Miramonte Dr. 2-1717

STOCKTON
Stockton Astronomical Society *‡
C. E. Spurgeon, 1429 S. Lincoln St.

WHITTIER
Whittier Amateur Astronomers *‡
J. Roth, Box 531.
Whittier Astronomical Society *†
R. N. Sturtridge, 8416 Davista Dr.

COLORADO

BOULDER
Boulder Astronomical Society *†
V. A. Ryan, 1629 North St. HI 2-6223

COLORADO SPRINGS
Colorado Springs Astronomical Society *
R. C. Moore, 2427 Paseo Rd. ME 3-7181

DENVER
Denver Astronomical Society *†°
E. H. Bronstein, 1747 S. Jasmine (22). SK 6-3232

PUEBLO
Pueblo Astronomical Society *†‡
Mrs. M. Struthers, 2329 E. Routt Ave. LI 3-1833
Pueblo Junior Astronomical Society †‖
H. Niethammer, 839 Van Buren. LI 4-2819

CONNECTICUT

MIDDLETOWN
Central Connecticut Amateur Astronomers *†
W. Fellows, R.F.D. 1, Hebron Ave., Glastonbury. ME 3-1871

NEW HAVEN
New Haven Astronomical Society, Inc. †
Mrs. J. Plato, 427 Ridgeview Rd., Orange. SY 9-2524

NEW LONDON
Thames Amateur Astronomical Society *†
Mrs. R. W. Tumicki, R.F.D. 1, Box 497, Uncasville. TI 4-8336

STAMFORD
Fairfield County Astronomical Society *†
D. Mitchell, Cliffdale Rd., Greenwich. TO 9-1684

STRATFORD
Boothe Memorial Astronomical Society, Inc. *†
B. W. Reilly, Box 2272, Noble Sta., Bridgeport (8). ED 6-9287

TORRINGTON
Litchfield Hills Amateur Astronomy Club
Miss G. Weaver, 37 James St. HU 9-8168

DELAWARE

WILMINGTON
Delaware Astronomical Society *†
1301 Orange St. (1). OL 6-8364

DISTRICT OF COLUMBIA

WASHINGTON
National Capital Astronomers *†°
Miss P. Seips, Box 271 (4).

FLORIDA

DAYTONA BEACH
Daytona Beach Star Gazers
W. T. Thomas, 105 N. Halifax. CL 2-8049

EAU GALLIE
Indian River Astronomical Society *†
Mrs. H. M. De Paolo, 1353 Everglade Dr. 3213

EGLIN AIR FORCE BASE
Choctaw Astronomical Society *
R. M. Porter, Box 221, Shalimar. CH 4-5578

FT. LAUDERDALE
Ft. Lauderdale Astronomical Society †
Dr. F. Denniston, 915 N. E. 2nd St. JA 2-5224

JACKSONVILLE
Jacksonville Amateur Astronomers Club *†°
E. L. Rowland, Jr., 225 W. Ashley St. EL 4-8597

LAKELAND
Lakeland Astronics Society *
W. Scholl, 67 Fla. Southern Coll. MU 3-8475
Lakeland Astronomical Society *
Mrs. L. B. Bevis, Box 339, 406 E. Lime St.

KEY WEST
Key West Astronomy Club *†
Miss M. W. Turner, 95 Sigsbee Rd., Box 915. 6-9803

MIAMI
Gulfstream Astronomical Ass'n., Inc. *†
J. W. Doty, 447 Blue Rd., Coral Gables. MO 7-4968
Southern Cross Astronomical Society, Inc. *†
A. P. Smith, Jr., 1601 S.W. 10th St. FR 4-7145

ORLANDO
Amateur Astronomy Club of Orlando *
Mrs. R. Lee, 445 Rock Lake Dr. 5-9000

ST. PETERSBURG
St. Petersburg Amateur Astronomy Club *†
Mrs. J. D. Rains, 2830 10th Ave. N. 79-9854

TAMPA
Tampa Amateur Astronomical Society *†
E. Z. Randall, 407 W. Chelsea St. 33-6391

WEST PALM BEACH
Astronomers Club of the Palm Beaches †
Mrs. D. D. Sinclair, Box 1108. JU 2-6830

GEORGIA

ATLANTA
Atlanta Astronomy Club *†°
W. H. Close, 225 Forkner Dr., Decatur. DR 3-3945

MACON
Macon Amateur Astronomers Club *†
P. E. Haines, 505 Eldorado Dr. 5-5084

HAWAII

HONOLULU
Hawaiian Astronomical Society *
E. G. Linsley, B. P. Bishop Museum (17).

IDAHO

BOISE
Boise Astronomical Ass'n.
Miss L. Moulton, 1712 N. 28th.

IDAHO FALLS
Idaho Falls Astronomical Society *
Mrs. O. D. Hendrickson, 475 J St. JA 2-3474

TWIN FALLS
Southern Idaho Amateur Astronomers
N. Herrett, 1220 Kimberly Rd. RE 3-0868

ILLINOIS

CHICAGO
Chicago Astronomical Society *†
A. A. Hay, 8024 W. Winnemac Ave. (31).
Chicago Junior Astronomical Society †||
E. Zimmermann, 133 Franklin Ave., River Forest. FO 9-8186
Lincoln Park Astronomical Society ||
D. Fretland, 509 W. Deming Pl. (14).

DANVILLE
Danville Astronomical Society †||
D. D. Morrison, 5 E. Fairchild.

GALESBURG
Galesburg Amateur Astronomers *†
H. L. Horein, 1246 N. Morton Ave. 7337-2

GENEVA
Fox Valley Astronomical Society *
J. Zoda, 420 Fellows St., St. Charles. 5507

LEMONT
Argonne Astronomy Club *†
H. DaBoll, Box 299, Argonne Nat'l. Lab. 800, ext. 2711

LOMBARD
Tree Towns Astronomy Club †||
L. Ewing, 26 S. Westmore Ave. 4153-J

MOLINE
Popular Astronomy Club *†
H. J. Schieck, 3303 Coaltown Rd.

OAK PARK
Sirius Astronomical Society †||
Miss C. Resnick, 722 N. Lombard Ave. EU 6-4742

PEORIA
Astronomy Section, Academy of Science
R. P. Van Zandt, 1100 N. Parkside Dr. 4-5621

ROCKFORD
Rockford Astronomical Society ||
W. Fonvielle, 528 Howard Ave. 8-5969

INDIANA

EVANSVILLE
Evansville Astronomical Society *†
Dr. R. T. Dufford, 512 S. Weinbach Ave. (14). GR 6-7856

FT. WAYNE
Ft. Wayne Astronomical Society
Mrs. M. Winiger, R.R. 3, Hillegas Rd.

INDIANAPOLIS
Indiana Astronomical Society *†°
W. E. Wilkins, 6124 Dewey Ave. FL 7-5946

KOKOMO
Kokomo Astronomical Society *
P. Miles, Box 645. GL 2-9378

MADISON
Madison Junior Astronomy Society *||
T. A. Winkel, 607 N. East St.

SOUTH BEND
St. Joseph Valley Astronomical Society
R. Bargmeyer, 59597 S. Ironwood Rd. (14). AT 9-1963

IOWA

DES MOINES
Des Moines Div., Great Plains Astronomical Soc.
R. T. Morehead, R.R. 1, Beaver Ave.

MARSHALLTOWN
Central Iowa Astronomers *
J. C. Steffa, 404 E. Church St. 2-1264

WATERLOO
Northeast Iowa Div., Great Plains Ast. Soc. *†
Dr. H. L. Sisson, 405 E. Dale St.

KANSAS

TOPEKA
Topeka Astronomical Society
F. Pilcher, 803 Lindenwood St.

WICHITA
Wichita Astronomical Society *†
S. S. Whitehead, 425 N. Lorraine (8). MU 2-6642

KENTUCKY

LOUISVILLE
Louisville Astronomical Society †
Mrs. V. C. Lipphard, 2421 Calvin (6). TW 6-9084
Louisville Junior Astronomical Society *†||
D. Kleinman, 1414 Goddard (4). HI 1365-J

LOUISIANA

GRETNA
Gretna Astronomical Society
J. A. Gunther, 209 Newton St. FO 1-0034

LAKE CHARLES
Lake Charles Amateur Astronomers Club †
C. Fronczek, Rte. 1, Box 51, Westlake. HE 6-1797

METAIRIE
New Orleans Soc. for Advancement of Astronomy
J. Mickel, 1307 Ridgelake Dr. VE 3-8224

NEW ORLEANS
New Orleans Amateur Astronomers Ass'n.
W. E. Wulf, 2107 Annunciation St. (13). RA 0706

OPELOUSAS
Opelousas Amateur Astronomers Ass'n.
Dr. W. G. Owen, IV, 311 E. Tennis St. 3812

MARYLAND

BALTIMORE
Baltimore Astronomical Society *
Maryland Academy of Sciences, Pratt Libr. Bldg., 400 Cathedral St. (1). MU 5-2370

MASSACHUSETTS

CAMBRIDGE
Amateur Telescope Makers of Boston *†
W. R. Battersby, 14 Munroe Rd., Lexington. VO 2-2565
Bond Astronomical Club †
R. C. Smith, 519 Morrissey Blvd., N. Quincy (71). GR 2-1938

PALMER
Pioneer Valley Astronomy Club
R. E. Cavanaugh, 14 Lathrop St. 841-M

SPRINGFIELD
Springfield Stars Club *†°
J. E. Welch, 107 Lower Beverly Hills, W. Springfield. RE 4-9179

WEST HARWICH
Cape Cod Astronomy Club *
C. Perisho.

WORCESTER
Aldrich Astronomical Society *†
T. L. Agos, 1 W. Boylston Terr.

MICHIGAN

BATTLE CREEK
Battle Creek Amateur Astronomy Club †
Mrs. W. V. Eichenlaub, 47 Everett Ave. 2-3059

DETROIT
Detroit Astronomical Society, Inc. *†
T. W. Sulisz, 3310 Dartmouth (17). WA 8-8949

FLINT
Flint Astronomy Club †
Mrs. M. M. Klarich, 3520 Gloucester (3).

GRAND RAPIDS
Grand Rapids Amateur Astronomical Ass'n. *†
R. Bennett, 3410 Bird Ave. N.E.
Grand Rapids Junior Astronomical Society ||
B. Hymes, 1500 Seminole Rd. S.E. CH 1-1460

JACKSON
Jackson Astronomical Society
W. H. Ketts, Jr., 2901 Robinson Rd. ST 2-9731

KALAMAZOO
Kalamazoo Amateur Astronomical Ass'n. †
Mrs. V. Shellman, 3809 Allendale. FI 4-8295

LANSING
Lansing Amateur Astronomers *†
R. C. Elliott, 434 Cowley Ave., E. Lansing. ED 2-5241

PONTIAC
Pontiac-Northwest Detroit Astronomers Ass'n. *†
G. Carhart, 40 Hadsell Dr. FE 2-9980

SAGINAW
Saginaw Valley Astronomical Ass'n. *
R. Bauer, 4105 Oak Court, Midland. TE 5-7587

STURGIS
Sturgis Astronomy Group
Mrs. S. Butler, 805½ E. Main St. 464-J

MINNESOTA

EDINA
Edina Astronomy Club *†
D. Lane, 4006 W. 44th St.

MINNEAPOLIS
Minneapolis Astronomy Club †
Mrs. M. B. Haarstick, Science Mus., Pub. Libr. FE 8-0781
Minneapolis Junior Astronomy Club *||
Mrs. M. B. Haarstick, Science Mus., Pub. Libr. FE 8-0781

ST. PAUL
St. Paul Telescope Club *†
F. F. Miller, 1212 7th Ave. S., S. St. Paul. GL 5-5934

MISSOURI

FAYETTE
Central Missouri Amateur Astronomers *†
R. C. Maag, 820 S. Osage, Sedalia.

KANSAS CITY
Astronomy Club of Kansas City *†
Mrs. L. Kinsey, 1522 Brush Creek. WA 3-3410

ST. LOUIS
St. Louis Astronomical Society *†
Mrs. N. Fallert, 9804 Honeycut Lane (19). WO 1-8427

MONTANA

HELENA
Amateur Astronomy Club of Helena ||
Dr. T. J. Mentrum, 504 Power Bldg. HI 2-0293

NEBRASKA

OMAHA
Omaha Div., Great Plains Astronomical Soc.
R. Osborn, 2035 N. 53 St. GL 5431

NEVADA

RENO
Astronomical Society of Nevada ‡
A. A. Garroway, 2040 Meadow View Lane. FA 3-0696

NEW HAMPSHIRE

NASHUA
Merrimack Valley Astronomical Society *†
A. J. Barrett, R.F.D. 2, Reeds Ferry. HA 4-3243

NEWMARKET
Great Bay Amateur Astronomers *
Miss A. Geoffrion, Packers Falls Rd.

NEW JERSEY

CALDWELL
West Essex Astronomical Society
R. M. Greenley, 412 Bloomfield Ave. CA 6-6751

EATONTOWN
Society of Telescopy, Astronomy and Radio *
Mrs. T. B. Richey, 2038 Magill Dr. EA 3-1000, ext. 23114

JERSEY CITY
Gregory Mem. Obs. of Paul Revere Boys Club †||
P. J. Kocmalski, 339 Wayne St. (3).

PATERSON
North Jersey Astronomical Society
D. Trombino, 4-4D Alabama Ave. (3). MU 4-6867

ROSELLE PARK
Amateur Astronomers of Union County *†
K. D. Smith, 871 Dorian Rd., Westfield.

RUTHERFORD
Astronomical Society of Rutherford
Mrs. A. Cox, 478 Riverside Terr. WE 9-0453

TEANECK
Bergen County Astronomical Society †
P. A. Zipperle, 3 Golf Ave., Maywood.

NEW MEXICO

LAS CRUCES
Astronomical Society of Las Cruces *†‡°
J. E. Durrenberger, Box 625. JA 6-2968

ROSWELL
Pecos Valley Sky and Telescope Club *
Dr. R. R. Boice, Rte. 2, Box 163-A. MA 2-7171

NEW YORK

ALBANY
Albany Astronomical Ass'n. *†
A. L. Swider, 42 Hanes St. (3). 8-3784

BABYLON
Long Island Observers' Ass'n. *
J. A. Tosto, 8 Bacon Lane. MO 9-9173

BINGHAMTON
Astronomical Society of Broome County
Dr. H. Nitka, 46 Matthews St.
BROOKLYN
Junior Astronomy Club †‖
S. E. Strom, 1950 Andrews Ave., Bronx (53).
BUFFALO
Buffalo Astronomical Ass'n. *†
G. N. Rote, 82 Floradale Ave., Tonawanda. AM 8150
CORNING
Corning Astronomy Club *
Mrs. E. Johnston, 106 Jennings St. 2-5142
JAMESTOWN
Astronomers Guild of Jamestown *
B. Hanson, 613 Stowe St. 92-811
NANUET
Rockland Astronomical Society
A. Goldsmith, 29 W. Allison Ave., Pearl River.
NEW YORK
Amateur Astronomers Ass'n., Inc. *
Mrs. A. Pridmore, 201 W. 79th St., Room 1010 (24). EN 2-7100
ROCHESTER
Astronomy Section, Academy of Science †
Miss J. M. Brown, 460 Campbell St. (11). GE 8-7284-M
SCHENECTADY
Schenectady Astronomy Club *†°
C. E. Johnson, 102 State St. DI 6-9522
SYRACUSE
Syracuse Astronomical Society *†
C. D. Fuller, 130 Falls Blvd., Chittenango. NE 7-3395
TROY
Rensselaer Astrophysical Society *†
Dr. R. Fleischer, Rensselaer Polytechnic Inst. AS 2-4678
Troy Astronomy Club †
J. T. Watkins, Valley Falls. PL 3-4195
UTICA
Utica Amateur Astronomers *†
W. Burak, Sr., 1663 Lincoln Ave.
WANTAGH
Long Island Astronomical Society
A. R. Luechinger, 2009 Seaford Ave. SU 5-1571
YONKERS
Hudson River Museum Astronomy Club °
J. A. Yules, 616 E. Lincoln Ave., Mt. Vernon. MO 8-0828

NORTH CAROLINA

CHAPEL HILL
Chapel Hill Astronomy Club *†
Miss M. I. Perry, 9 Maxwell Rd. 9-6334
CHARLOTTE
Charlotte Amateur Astronomers Club *†
F. Selby, 200 S. Laurel Ave. (7). ED 3-3933
GREENSBORO
Greensboro Astronomy Club *†
Dr. A. D. Shaftesbury, 315 Tate St. 2-6528
WINSTON-SALEM
Forsyth Astronomical Society *†
K. A. Shepherd, 903 West End Blvd. 2-1631

NORTH DAKOTA

GRAND FORKS
Red River Astronomy Club *†
L. B. Speare, 1925 Viets Ave. 4-4705

OHIO

AKRON
Astronomy Club of Akron *
Mrs. R. J. Couts, 878 Kennebec Ave. (5). ST 4-8450
BAY VILLAGE
Lake Erie Jr. Museum Junior Astronomers †‖
Mrs. E. W. Fleming, 630 Canterbury Rd. TR 1-3742
CINCINNATI
Cincinnati Astronomical Ass'n. *
G. A. Lineback, 2933 Cortelyou Ave. JE 1-1442
Cincinnati Astronomical Society, Inc. *†
Mrs. D. H. Watson, 8822 De Soto Dr. (31). WE 1-5919
CLEVELAND
Cleveland Amateur Telescope Makers
Museum of Natural History, 2717 Euclid Ave. PR 1-0909
Cleveland Astronomical Society
Warner and Swasey Obs., Taylor Rd., E. Cleveland (12). GL 1-5625
COLUMBUS
Battelle Astronomy Club *
J. W. Kissel, Battelle Mem. Inst., 505 King Ave. AX 9-3191, ext. 363-2330
Columbus Astronomical Society *†
Mrs. J. Gann, 420 N. Cassady Rd. (9). CL 2-8421
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Dayton Astronomy Club *
R. Walters, 5384 Cornwall Dr. (15). CR 7-9022
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Hillsboro Astronomical Society *
Mrs. D. N. McBride, Box 85. 1169
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Lima Astronomy Club *
Miss C. Klaserner, 1593 Allentown Rd.
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Marietta Astronomical Society °
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TOLEDO
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E. D. Edenburn, 4124 Commonwealth Ave. (12). CH 3-3558
WARREN
Mahoning Valley Astronomical Society *
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YOUNGSTOWN
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Mrs. M. Krutsinger, 6525 N. E. Davis (16). AL 4-1491
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Shaler Township Junior Amateur Astronomers ‖
C. Raible, 200 Rebecca Sq. (9). TA 1-2171
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Rittenhouse Astronomical Society *†
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F. M. Garland, 127 Park Pl., McKnight Village (9).
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Allegheny Valley Amateur Astronomers *°
W. E. Stocks, 215 Carson St. BR 4-8835
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Washington County Astronomy Club *
Mrs. L. Withrow, R.D. 1, Eightyfour. WI 1-7191
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Astronomical Society of Waynesboro *
R. H. Helfrick, R.F.D. 3. 1908-R1-4
YORK
York Astronomical Society *
J. N. Lewis, 157 Scarboro Dr. 8-1080

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Skyscrapers, Inc.
G. E. Gregory, 585 Elmgrove Ave., Providence (6).

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Hartsville Astronomical Society ‖
B. Hopkins, Box 423. 1540

SOUTH DAKOTA

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Rapid City Astronomical Society *
Dr. R. F. Heckman, S. D. State School of Mines and Technology.

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CHATTANOOGA
Barnard Astronomical Society *†
A. H. Jones, 411 W. 21st St. VE 1-2244
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Kingsport Astronomical Society *
J. Brown, 1329 Belmeade Dr. CI 5-7513
MEMPHIS
Memphis Astronomical Society *†
S. P. Franklin, 5030 Lynbar. MU 3-9737
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Dr. C. K. Seyfert, Vanderbilt Univ. AL 4-5611
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R. O. Riggs, Box 42. 3781

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Brownfield Astronomy Club *
C. Isbell, Rte. 1. 2074
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Texas Astronomical Society †°
E. M. Brewer, 5218 Morningside Ave. (6). TA 6-3894
EDINBURG
Magic Valley Astronomical Society †
P. R. Engle, Pan American Coll. Obs. DU 3-1151
FT. WORTH
Ft. Worth Astronomical Society *†
M. G. Vinson, 1111 W. Sanford, Arlington. CR 4-9300
Junior Astronomy Club of Children's Mus. †‖
Miss C. M. Noble, 1511 Cooper St. (4). ED 2-9892
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East Texas Astronomical Society *†
T. H. Anderson, Jr., 601 Highland Dr.
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San Angelo Amateur Astronomers Club *
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San Antonio Astronomy Club *†
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Norfolk Astronomical Society *†°
A. D. Hustead, Weather Bur., Municipal Airport (13). LO 3-4368
RICHMOND
Richmond Amateur Junior Astronomers ‖
Dr. E. C. Hoff, 117 Gaymont Rd. (26). 88-3368
Richmond Astronomical Society *
B. S. Ragland, 601 E. Franklin St. (19). 2-3043
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Amateur Astronomers of Roanoke *†
W. B. Daniel, 2202 Richlieu Ave. S.W. 3-2637

WASHINGTON

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N. C. Dalke, 8017 Stroud Ave. (3). PL 7498
SPOKANE
Amateur Telescope Makers of Spokane *†
L. Bolch, 4023 E. 32nd Ave. (34). KE 4-8748
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Tacoma Amateur Astronomers †
Mrs. R. H. Atkinson, 2816 N. Union Ave. (7). PR 1492
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Yakima Amateur Astronomers *†
E. J. Newman, 324 W. Yakima Ave. GL 2-9825

WEST VIRGINIA

FAIRMONT
Fairmont Amateur Astronomers Ass'n., Inc. †
D. Brown, 1255 Fennimore St. 629
WHEELING
Oglebay Inst. Astronomical Ass'n.
R. W. Schramm, Speidel Obs., Oglebay Inst. WO 2125

WISCONSIN

BELOIT
Beloit Astronomical Society *†
Dr. K. E. Patterson, 304 Public Service Bldg. EM 5-7662
MADISON
Madison Astronomical Society †°
Dr. C. M. Huffer, Washburn Obs., Univ. of Wisconsin. AL 5-3311, ext. 2551
MILWAUKEE
Milwaukee Astronomical Society *†
E. Halbach, 2971 S. 52nd St. LI 1-1181
OSHKOSH
Fox River Valley Amateur Astronomers Club *†
J. H. Wojahn, 250 Lark St. BL 8171
RACINE
Racine Astronomical Society
Mrs. P. B. Carey, 1806½ Clayton Ave. ME 2-2278
SHEBOYGAN
Sheboygan Astronomical Society
E. Parnitzke, Jr., Rte. 2.

WYOMING

CHEYENNE
Cheyenne Amateur Astronomers *†
Mrs. P. Doran, 2706 E. 10th St. 2-3910

The Astronautic Chart

Roy C. Spencer, *Missile Systems Laboratory*
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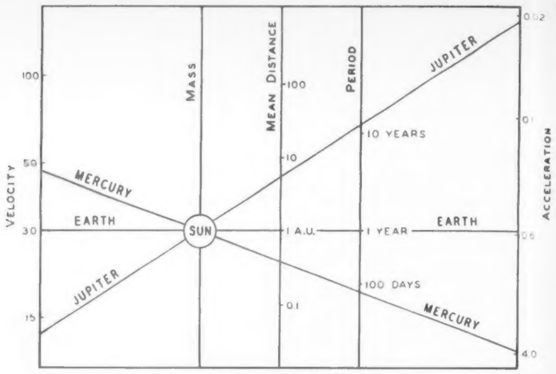


A small-scale, simplified portion of the Astronautic Chart. The earth-sun solution is horizontal.

Launching of the first seven artificial earth satellites has again focused the attention of students and scientists on the laws of Kepler and Newton that control the paths of the planets around the sun, and of natural satellites around their planets. These laws apply as well to the motions of artificial satellites.

The specialist in celestial mechanics or space travel deals with orbit problems that become very intricate when precise answers are needed. But a general understanding of the physical laws and their application is much easier to attain. In fact, with the aid of the Astronautic Chart on pages 574 and 575 of this issue, the amateur can quickly obtain an appreciation of motions within the solar system. This simple graphical device shows at a glance the interrelations among distances, orbital periods, and masses.

The diagram is a nomograph or alignment chart, so arranged that a single oblique line gives the characteristics of a particular orbit. The oblique lines illustrate numerous systems of bodies in orbital motion; other lines may be drawn to solve problems concerning possible future satellites, or asteroid orbits.

The five vertical scales indicate, from left to right:

V. Average orbital velocity, in kilometers per second. For a circular orbit, this is the constant velocity of the moving body. If the orbit is an ellipse, *V* equals the square root of the product of the velocities at perihelion and aphelion, or at perigee and apogee.

M. Mass of the central body, in terms of the sun's mass as a unit. Strictly speaking, this is the combined mass of the two bodies, but for graphical purposes the mass of any planet or satellite can be regarded as negligible compared to the mass of its primary. (Only our moon has a mass as great as 1/80 of its central body.)

a. Mean distance from the primary body, expressed in A.U. or kilometers. In the case of an elliptical planetary orbit, this is the average of the perihelion and aphelion distances. One astronomical unit (A.U.) is the mean distance of the earth from the sun, about 93 million miles.

P. Period of orbital revolution, expressed in years at the top. This scale is successively changed to days, hours, and minutes, to fit the short periods in the lower part of the chart.

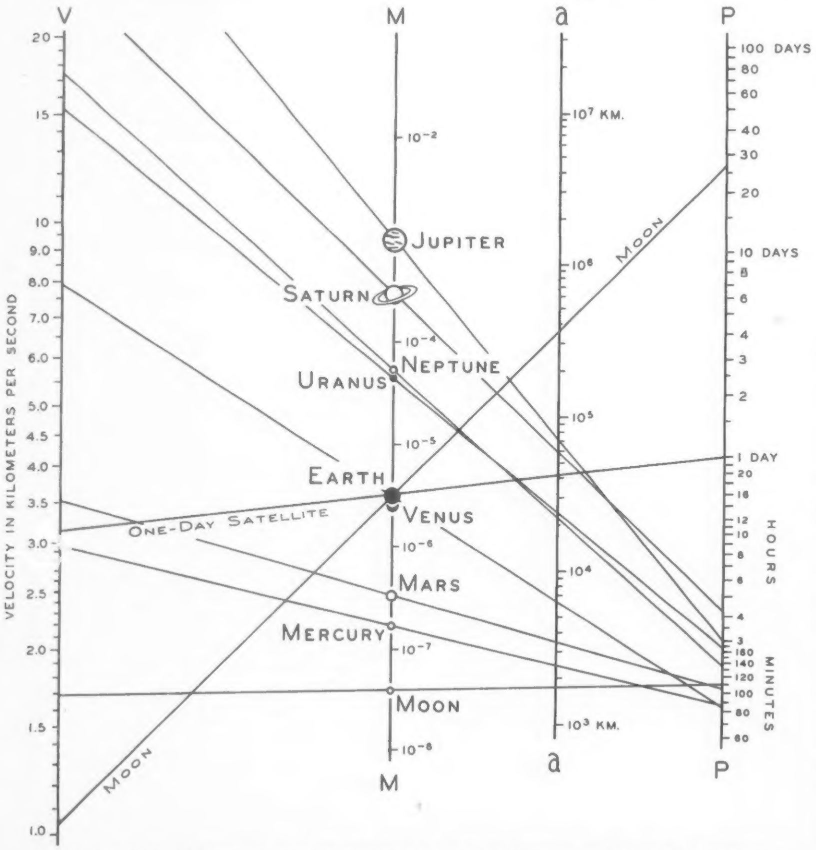
g. Average acceleration toward the central body, expressed in centimeters per second each second. For example, in the case of Jupiter, this is the velocity of free fall toward the sun, one second after starting from rest, of a body at Jupiter's distance from the sun.

Using the Chart

As an example of the use of the Astronautic Chart, consider the planet Saturn, which moves around the sun in a period of about 29½ years. Lay a straightedge across the chart, passing through the points marked "sun" on the **M** scale and just below 30 years on the **P** scale. Extended to the left, this straight line shows that Saturn's orbital velocity is some 9½ kilometers per second. From the intersection with the middle scale, the mean distance of Saturn from the sun is about 9.5 astronomical units, and the right-hand scale shows that the planet's acceleration toward the sun is much less than 0.01 centimeter per second per second.

There are corresponding lines drawn through the sun for the other principal planets, from Mercury to Pluto, as well as for a representative asteroid, Ceres.

In the lower part of the chart, each planet is indicated at the proper place on the mass scale. Through the planet symbols are drawn straight lines giving chart solutions for some of their satellites. The line for Jupiter's brightest moon, III (Ganymede), provides the following information: orbital velocity about 11 kilometers per second, distance from Jupiter over a million kilometers, period seven



Each line plotted here represents the orbit for a minimum satellite of a planet. The moon and a one-day earth satellite have been included.

days, and acceleration toward the planet 11 centimeters per second each second.

There is quite an overlap for some members of the solar system in both acceleration and velocity. For instance, the acceleration of our moon toward the earth approximates that of Mars toward the sun. Also, the velocities of the earth's present artificial satellites are about the same as the orbital velocity of Uranus around the sun.

Artificial Satellites

An important use of the chart is the solution of problems involving earth satellites, whether natural or artificial. Two shaded lines run diagonally through the earth symbol on the mass axis, one for the moon, the other for a hypothetical satellite that would just graze the earth's surface. The double triangle bounded by these lines is the chart area including all possible earth satellites closer to us than the moon, that is, *cislunar.*

Three actual satellites have been plotted, 1957α, 1958α, and 1958β, showing the range in initial period that includes all the others launched to the present.

Space-travel enthusiasts who expect that some day man-made satellites will be circling other planets to observe them close at hand will find use for the chart on page 572, on which minimum satellites have been plotted for all planets except Pluto and Venus. Each such satellite is presumed to circle its primary just above the surface we see, whether that surface is solid, as on Mercury and Mars, or gaseous, as on Jupiter and Saturn.

The minimum-satellite velocities differ widely, yet their periods are of the same order, ranging from over four hours for a minimum satellite of Saturn to 84.5 minutes for one of the earth. This is because the period for a spherical planet depends only on the planet's density. All spheres with the earth's density would have minimum-satellite periods of 84.5 minutes. A sphere of ice, whether 10 miles in diameter or the size of Jupiter, would have a period of about three hours for such a grazing moonlet.

On the full-sized Astronautic Chart, extending any minimum-satellite line to intersect the acceleration (g) scale indicates the surface gravity of the planet, for example, 980 centimeters per second per second for the earth. (This approximation would be exact if the planet were spherical and nonrotating.)

Recently there has come into general use the term *circumlunar satellite,* for bodies, natural or artificial, in orbital motion around the moon. The Astronautic Chart also serves to answer numerical questions about these objects, which perhaps are soon to be included among the known members of the solar system. As an example, a line has been drawn in the minimum-satellite chart for a minimum circumlunar vehicle. From this we see that a rocket ship just clearing the lunar surface would require about 110 minutes to make a trip around the moon. The reader may easily find the orbital velocity and period of a rocket revolving around the moon at a distance above its surface of, say, 900 kilometers (2,638 kilometers from its center).

Construction of the Chart

The scales for mass, mean distance, and period provide a solution for Kepler's third or harmonic law, which holds for elliptical as well as circular orbits:

$$a^3/P^2 = GM/4\pi^2, \qquad (1)$$

in which G is the constant of gravitation. We can set up the following expressions, in terms of the mean orbital velocity:

$$M = V^4/Gg;\ a = V^2/g;\ P = 2\pi V/g. \qquad (2)$$

(As a check, substituting these values into Equation 1 yields an identity.)

Many readers are familiar with the multiplication nomograph or alignment chart for an equation of the form $z = xy$. On plotting boards for navigators, such nomograms are used to relate speed, time, and distance traversed, requiring only the use of a straightedge to read the value of one of these when the other two are known. Thus, in the simplest form, x and y are parallel logarithmic scales with the same logarithmic base, while the scale for z is placed *midway* between them with a logarithmic base *half as great.*

Actually, there is some flexibility in the choice of the logarithmic bases, as shown in the diagram seen below for the case of $z = x^n y$. Choose any convenient base A for the cycle from 1 to 10 of the x scale. Then divide by n as shown on the left. On the right, any convenient base B is shown for scale y. The intersection of the diagonals of the parallel line segments A/n and B are then marked off to find the *position* and *length* of the base C for z.

It can be shown from the construction that the position of the z scale is determined by

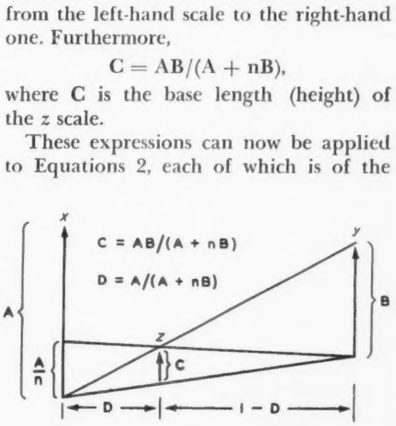
$$D = A/(A + nB),$$

where D is the fraction of the distance from the left-hand scale to the right-hand one. Furthermore,

$$C = AB/(A + nB),$$

where C is the base length (height) of the z scale.

These expressions can now be applied to Equations 2, each of which is of the

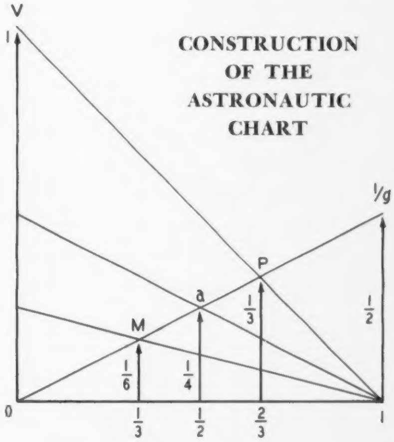


Nomograph for $z = x^n y$, with A, B, and C the respective logarithmic scales.

form $z = V^n \times 1/g$. For convenience, let the logarithmic base for **V**, the left-hand scale of the Astronautic Chart, be of unit length – represented by 1. For the right-hand scale we adopt a base half as long – represented by $\frac{1}{2}$. Our choices make $A = 1$ and $B = \frac{1}{2}$.

In Equations 2, n has the value 4, 2, and 1, for the **M,** **a,** and **P** scales respectively. Substituting these values in the expressions above for D and C gives the following table:

Scale	V	M	a	P	1/g
Position	0	$\frac{1}{3}$	$\frac{1}{2}$	$\frac{2}{3}$	1
Base	1	$\frac{1}{6}$	$\frac{1}{4}$	$\frac{1}{3}$	$\frac{1}{2}$



CONSTRUCTION OF THE ASTRONAUTIC CHART

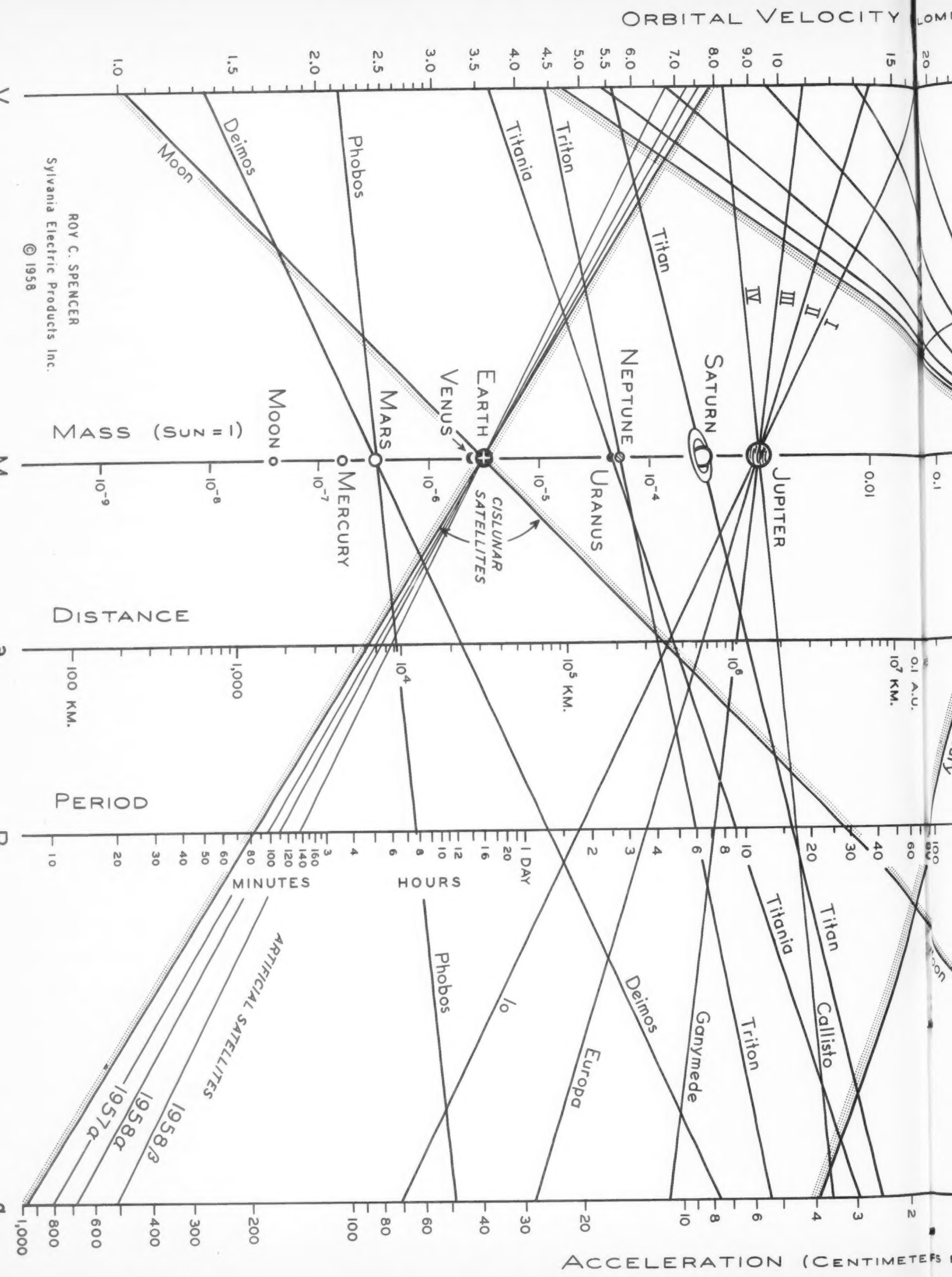
The reader who wishes to subdivide further the scales of the Astronautic Chart will find the proper values in any scale of logarithms to the base 10. If, for example, the marks 1.0 and 10.0 are one inch apart on the scale, the marks should be put at the following intervals from the mark for 1.0 (which corresponds to 0.0, as the logarithm of one is zero):

1	2	3	4	5
0.000	0.301	0.477	0.602	0.699
6	7	8	9	10
0.778	0.845	0.903	0.954	1.000

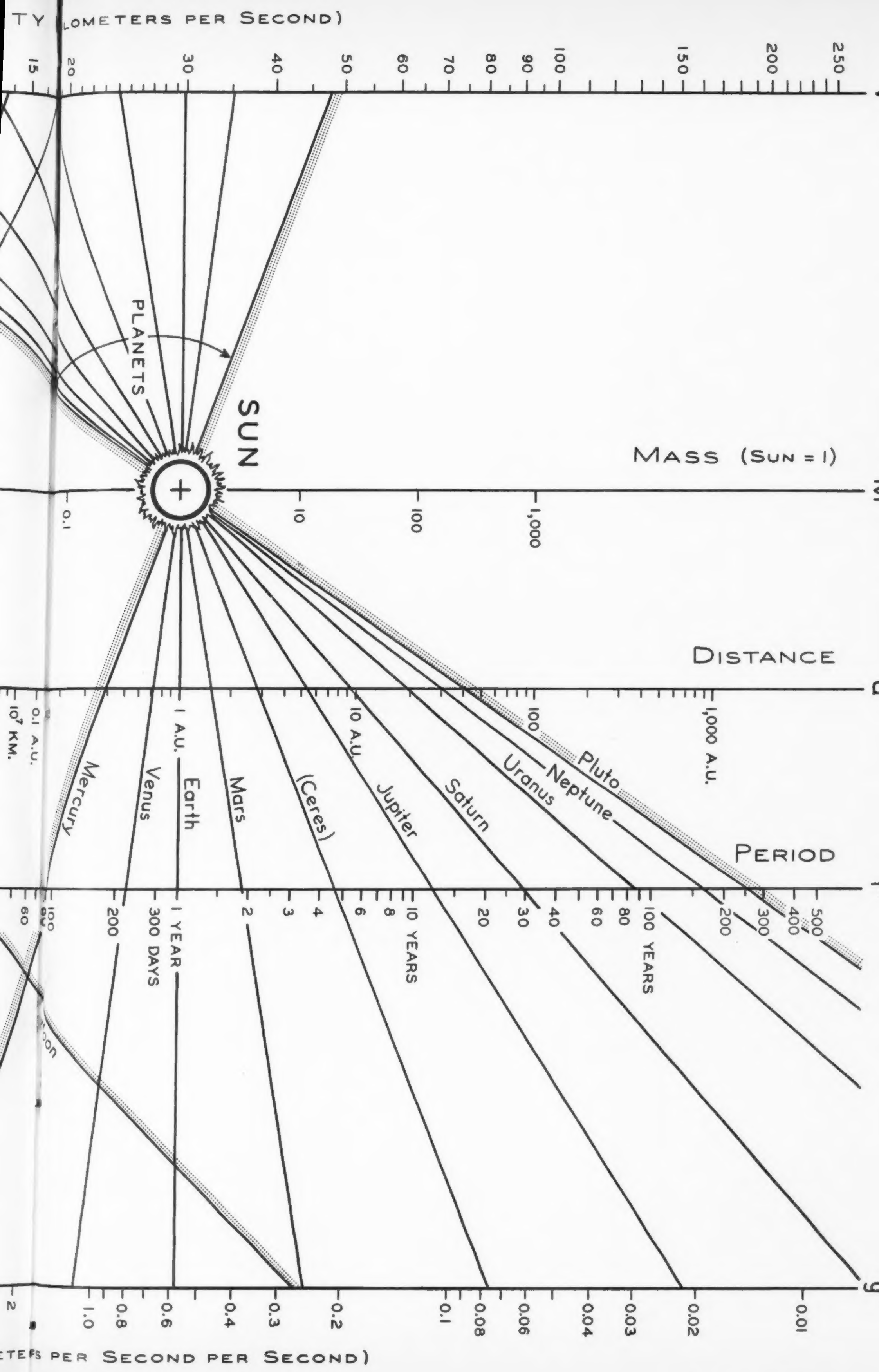
For the right-hand scale of the Astronautic Chart, our solution gives $1/g$ instead of g itself. This is easily taken care of by reversing the logarithmic scale, so the values of g increase downward instead of upward.

Further information about nomograms and their construction may be found in such texts as *Elements of Nomography,* Raymond D. Douglass and Douglas P. Adams, McGraw-Hill Book Co., New York, 1947. See also *Graphical Solutions,* C. O. Mackey, John Wiley and Sons, New York, 1936.

Originally I had inserted several orbits of binary stars, such as Capella and Sirius, but later decided to omit them in order to simplify the chart and restrict its illustrations to the solar system. But whether your hobby is earth satellites, interplanetary exploration, double stars, or a combination of these, the Astronautic Chart can be used to study them further.


ORBITAL VELOCITY
V
M
a
P
g
MASS (SUN = 1)
DISTANCE
PERIOD
ACCELERATION
ROY C. SPENCER
Sylvania Electric Products Inc.
© 1958
Moon
Deimos
Phobos
Titania
Triton
Titan
IV
III
II
I
MOON
MERCURY
MARS
VENUS
EARTH
NEPTUNE
URANUS
SATURN
JUPITER
CISLUNAR SATELLITES
100 KM.
1,000
10^4
10^5 KM.
10^6
10^7 KM.
0.1 A.U.
MINUTES
HOURS
1 DAY
ARTIFICIAL SATELLITES
1957α
1958α
1958β
Io
Europa
Ganymede
Callisto

Astronautic Chart



OBSERVER'S PAGE

Universal time is used unless otherwise noted.

Mercury, Venus, and Regulus in the Morning Sky

To an observer suitably situated on the early morning of September 10, 1958, the planet Mercury will appear so close to the star Regulus that they will seem to coalesce into a single naked-eye object. Good binoculars should still separate them, however, and in a telescope they will look like a wonderful double star.

The planet will be visible to the naked eye from about September 5th to 20th, perhaps a few days earlier and later for experienced observers. It will be quite close to Regulus, and about four times brighter than the star, on the mornings of the 9th, 10th, and 11th, with its nearest approach on the 10th at 4 a.m. Eastern standard time (5 a.m. daylight saving time). Mercury will rise between $1\frac{1}{4}$ and $1\frac{1}{2}$ hours before the sun, depending on the observer's latitude, and can best be seen about 50 or 55 minutes before sunrise.

Thus, the period of apparent coalescence with Regulus will be at the time of Mercury's best visibility from the Atlantic seaboard. Along the Mississippi River, the star and planet will rise very close together, but probably distinguishable without optical aid. Farther west the separation will be small, but nevertheless distinct. The reason is that the western observers have to wait until later for the planet to rise and become visible, so it will have passed Regulus.

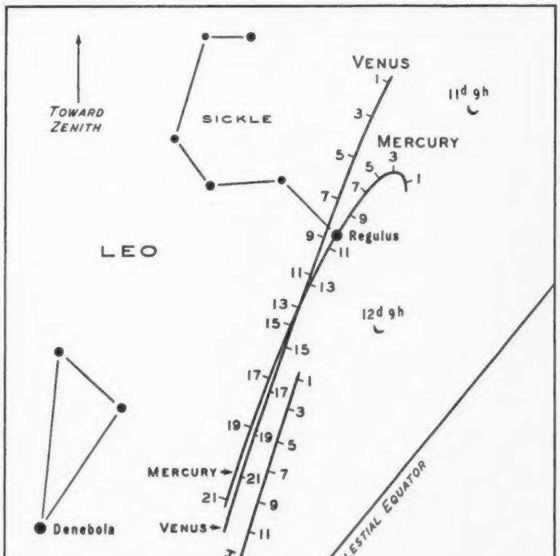
Amateurs wherever situated should note the position of Mercury relative to Regulus on the mornings before and after the conjunction. The planet's positions are shown for 0^h Universal time in the accompanying chart.

Mercury will be at the apex of a huge isosceles triangle containing Pollux and Procyon at the other corners. Observations will be greatly aided by the presence of Venus nearby. It will be about 15 times as bright as Mercury, the two planets rising nearly at the same time a day or two after their conjunction in right ascension on September 5th.

On the morning of the 6th, Venus and Mercury will be only $1\frac{1}{2}$ degrees apart, with Mercury to the right. Regulus will be several degrees below them, but they will both approach the star, and on the morning of the 9th the three objects will form a flat triangle. By September 11th the moon will enter the picture, a thin crescent two days before new moon. It will be some 10 degrees from them, but photographers can include it in a wide-angle picture or make it part of a general horizon view.

After September 12th, Mercury and Regulus will separate rapidly, but the former will draw closer to Venus, being within half a degree of it on the mornings of the 17th, 18th, and 19th. Thus, they will be visible in a telescope field that would show the whole moon — about half a degree in diameter.

On September 5th, Mercury will appear



The eastern morning sky in September. Venus and Mercury are in Leo, and their motions are marked at two-day intervals. The position of the sun, on the ecliptic, is also shown. The moon symbols for the 11th and 12th show where it will be located near the time of sunrise. The chart is oriented for an observer whose latitude is 40° north.

as a crescent in a fair-sized telescope, and at greatest western elongation, on the 9th, it will be of the quarter (half-full) phase, thereafter gibbous. A telescope of sufficiently wide field and power will show Venus as nearly full phase and Mercury as gibbous at the time of their second conjunction, on September 18th.

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JULY 8-9 AURORA

AFTER receiving reports from Japan, Australia, and Hawaii of a type 3 solar flare (the type of largest activity), the National Bureau of Standards radio forecasting center at Ft. Belvoir, Virginia, declared an IGY special world interval. This meant that the 24-hour period of July 8-9 was to be a time of intensive observations for the International Geophysical Year.

That evening a display of northern lights was seen from several sites in the United States and Canada. At Eightyfour, Pennsylvania, David R. Kaiser first observed the aurora at 10 p.m. Eastern standard time. There was a red glow of medium intensity in the west to a height of 20 degrees; in the northwest, a low-lying greenish area 10 degrees high with a red glow above it extending to 25 degrees; and in the east, a red glow to 15 degrees.

From Chesterfield, New Hampshire, at about 10:30 p.m. Leo Mattersdorf and his son-in-law viewed rays shooting up from the western and northern horizons to points south of the zenith. Ursa Major was in the midst of the display. A curtain effect was visible in the northwest, of a very pale green.

Alan and Perry Bowker, Oakville, Ontario, arose at 1 o'clock to make their usual meteor observations, but the intense aurora made this impossible. The whole sky was covered with activity for long periods of time, rather than the usual localized arcs. The climax occurred at 2:45 a.m., with the entire southern sky pulsating and a long folded curtain with red upper fringes dominating the north.

From Louisville, Kentucky, Ed Pape watched the display for about two hours; there it was mainly white. In Slick Rock, Colorado, Glenn F. Mustee saw the aurora as gray to gray-blue, with no trace of red. The aurora reached about 30 degrees above the horizon, and extended some 15 degrees east and west of Polaris. A similar appearance was observed by James Kuschel of Port Huron, Michigan.

Another display of northern lights had been seen on June 28-29 in New England. Observing from Bristol, New Hampshire, Theodore L. Agos of Worcester, Massachusetts, saw the brighter portion of the activity begin at 11:15 p.m. Eastern standard time. It started in the east and extended past the zenith, culminating in a corona-type aurora centered in the magnetic zenith about 10 degrees south of the overhead point. Strong rays and pulsating patches dominated the display, which was observed and photographed by Mr. Agos until 1 a.m. The picture on page 564, one of many he took of the varied forms, shows the fine structure of the corona and stars in Lyra.

SUNSPOT NUMBERS

The following American sunspot numbers for June were derived by Dr. Sarah J. Hill of Whitin Observatory, Wellesley College, from AAVSO observations.

June 1, 139; **2,** 115; **3,** 148; **4,** 202; **5,** 216; **6,** 185; **7,** 165; **8,** 182; **9,** 161; **10,** 189; **11,** 172; **12,** 162; **13,** 180; **14,** 115; **15,** 86; **16,** 65; **17,** 86; **18,** 96; **19,** 127; **20,** 126; **21,** 135; **22,** 175; **23,** 195; **24,** 164; **25,** 162; **26,** 205; **27,** 175; **28,** 181; **29,** 133; **30,** 121. Mean for June, 152.1.

Below are observed mean relative sunspot numbers from Zurich Observatory and its stations in Locarno and Arosa.

July 1, 180; **2,** 164; **3,** 190; **4,** 213; **5,** 222; **6,** 240; **7,** 231; **8,** 218; **9,** 207; **10,** 219; **11,** 165; **12,** 137; **13,** 149; **14,** 143; **15,** 142; **16,** 144; **17,** 160; **18,** 181; **19,** 196; **20,** 192; **21,** 208; **22,** 184; **23,** 178; **24,** 170; **25,** 179; **26,** 213; **27,** 238; **28,** 250; **29,** 274; **30,** 280; **31,** 263. Mean for July, 197.7.

Zurich predictions for smoothed monthly sunspot numbers are: August, 169; September, 165; October, 161; November, 157; December, 153.

DEEP-SKY WONDERS

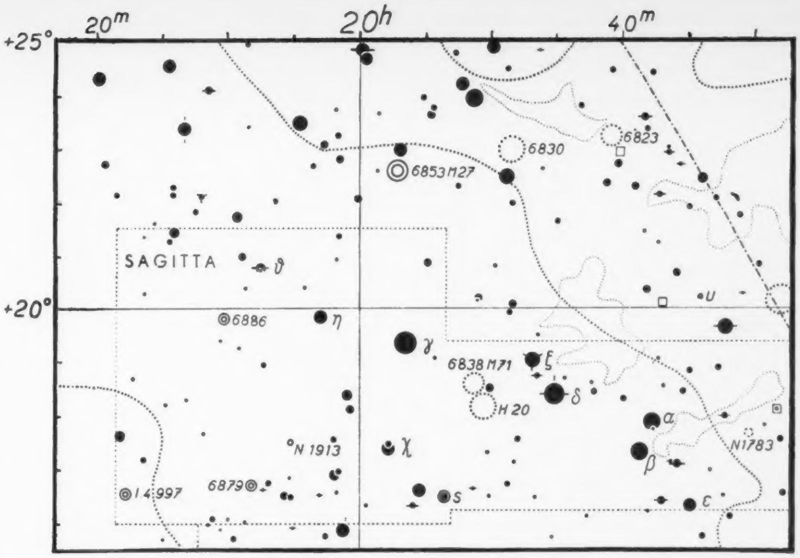
SAGITTA is one of the best known of the very small constellations, now conveniently placed for viewing in the evening sky. Many amateurs use it as a guide to find the splendid Dumbbell nebula in nearby Vulpecula. (This giant planetary, visible even in very small telescopes, is Messier 27, whose 1950 co-ordinates are $19^h\ 57^m.5$, $+22°\ 35'$.)

Several interesting deep-sky objects within Sagitta itself are marked on the accompanying chart. Close to the shaft of the Arrow lies M71 (NGC 6838), listed by Helen Sawyer Hogg as a globular cluster, but earlier sometimes called a galactic cluster. Quite easy to find at $19^h\ 51^m.5$, $+18°\ 39'$, it is 6′ in diameter. While small telescopes will show it, an aperture of at least 10 inches is needed for detailed views.

Less than a degree southwest of M71 is the cluster H20, a sparse scattering of stars some 10′ in diameter, so inconspicuous that it was not included in the *New General Catalogue*.

The chart shows three planetary nebulae in Sagitta — NGC 6879, 6886, and IC 4997 — but all are very inconspicuous objects of about magnitude 12 and only a few seconds of arc in diameter, lost in a rich Milky Way region. They may be recognizable in large telescopes.

Most of the many variable stars in Sagitta are faint, but S Sagittae is an interesting object for observations with binoculars. It is of the Cepheid type, varying between the visual magnitude limits 5.3 and 6.1 in an eight-day period. Two novae are marked on the chart. That of 1783 reached magnitude 6 but is now only 19; the 7th-magnitude nova of 1913, however, had a second maximum in 1946, and may well brighten up again from its present magnitude of 16.



The region of eastern Sagitta, from the Skalnate Pleso "Atlas of the Heavens."

Double star observers with small telescopes will want to view Zeta Sagittae, an easy pair of 5th- and 9th-magnitude stars separated by 8″. (The brighter component is a very close binary, beyond the reach of amateur instruments.) Theta Sagittae is another easy double, magnitudes 6 and 9, separation 12″.

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BOOKS AND THE SKY

ATLAS OF THE SKY

Vincent de Callatay. St. Martin's Press, New York, 1958. 157 pages. $12.50.

HERE IS a thoroughly comprehensible and complete atlas of the heavens as visible to the naked-eye observer. Unhindered by the arrows, numbers, or gimmick charts so often incorporated in similar books for the amateur, the 36 plates clarify study of the stars by simply looking like what one sees.

With white dots on a black background, and only very faint lines connecting the major stars of the constellations, the author has presented the entire sky as seen from different latitudes in nine general charts, and again in 27 charts which together include the 88 constellations.

Accompanying each plate of several constellations are other charts of the standard figures, in black ink on white paper. The latter supply lines of declination and right ascension; constellation names, official boundaries, and brightest stars; distances in light-years; star designations, general characteristics, and magnitudes of those over 4th magnitude; variable stars; star clusters; and Messier objects.

Both the negative and positive charts show the stars down to magnitude 5.5, easily visible to the unaided eye. The system of two charts, one of which may be easily compared with the true sky, greatly facilitates study or identification. Further information on the location of a constellation and its visual appearance is included in several paragraphs accompanying each plate.

Concise and accurate descriptions are given of many other types of celestial objects and phenomena, excluding the solar system. When an example of some interesting class of object has been cited as belonging to a constellation, a description of that object and others similar to it follows. For instance, in the section dealing with Ophiuchus, mention is made of Barnard's star, which leads to an excellent explanation of the proper motions of stars; in the section concerning Gemini, spectroscopic binaries are described, the star Castor being cited as an example; in the page on Hercules, M13 naturally leads into the story of globular clusters.

A preface by Sir Harold Spencer Jones, who translated the original French text of the atlas, and a conclusion comprising 12 telescopic photographs to illustrate various phenomena complete this beautiful book for the serious amateur who is anxious to find his way about the sky and learn of what he sees. It is not surprising that Vincent de Callatay was awarded the Prix Edouard Mailly by the Royal Academy of Belgium for his *Atlas of the Sky*.

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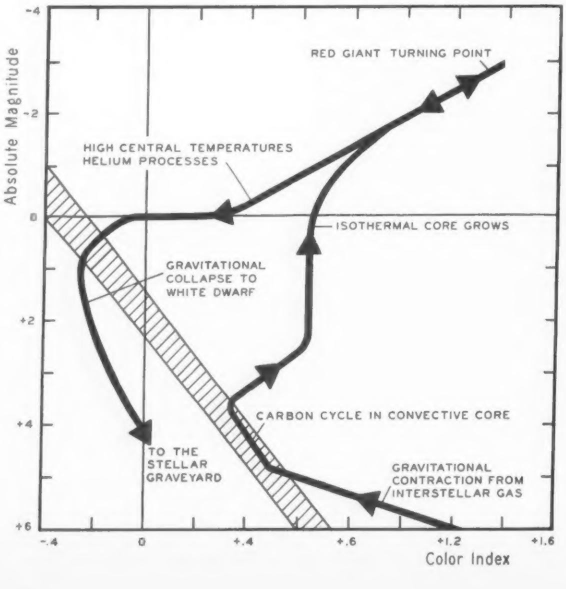
THE ASTRONOMER'S UNIVERSE

Bart J. Bok. Melbourne University Press, Carlton, N.3, Victoria, Australia, 1958. 107 pages. 21s.

IN 100 PAGES and with 24 photographs of celestial objects, the director of Mount Stromlo Observatory in Australia presents a very readable account of the active phases of modern astronomy. His writing is based on a series of lectures at the University College at Canberra, and covers the solar system, stars, the Milky Way system, and ages and evolution.

Dr. Bok has made no attempt to include all fields of astronomy, yet a more concise over-all description of current research can hardly be found anywhere.



Bart J. Bok has drawn this chart showing the probable evolution of a star having a mass slightly greater than the sun's. The shaded line represents the main sequence, the heavy line the development of a star, starting from the lower right. The star becomes a red giant and finally evolves into a white dwarf. Adapted from "The Astronomer's Universe," Melbourne University Press, 1958.

In the first three chapters he restricts himself to known facts, and only in the final one does he depart from this "cautious approach" while considering the expanding universe, the cosmic time-scale, and stellar evolution. Reproduced with this review is the diagram from page 87 of the probable evolution of a star with a mass slightly greater than that of the sun, based mostly on calculations by F. Hoyle and M. Schwarzschild.

The volume has been well manufactured, but the halftones are contrasty and might have been printed better.

It has recently been announced that this book is to be published in the United States this fall by Cambridge University Press, New York.

C. A. F.

OPTICS

Bruno Rossi. Addison-Wesley Publishing Co., Inc., Reading, Mass., 1957. 510 pages. $8.50.

THE SIMPLE WORD "optics" carries a vast burden; it blankets such seemingly diverse topics as rainbows, shadows, the photograph of a friend, the radial velocity of a star, one's reflection in a mirror, the world of the microscope, the realm of the telescope, and the amusement-park horror house of optical illusion.

Consequently, a book titled *Optics* cannot be judged from its name. In last November's *Sky and Telescope,* this writer reviewed another excellent work (Vasco Ronchi's *Optics: The Science of Vision*), which bears so little resemblance to Rossi's that it might well be thought a book on another subject. This arises not only from the broad scope of optics, but from the different viewpoints these authors apply even to such standard subdivisions as geometrical optics, physical optics, optical instruments, and physiological optics.

This volume by Rossi, a physicist who has won international renown in the field of cosmic rays and high-energy physics, is described as a textbook for advanced undergraduate students. It appears eminently suitable for such students in technical institutions. But in other colleges, the book seems more suited to first-year graduate work. For anyone who desires a solid grounding in physical optics based on a thorough development of the wave model of light and Huygens' principle, this book is enthusiastically recommended.

The text reflects the outstanding ability of the author as a research physicist. He rarely belabors a topic needlessly, yet he seldom glosses over difficult points that many authors tend to avoid on the excuse that their book is intended as an introduction to the subject. Nonetheless, Rossi's exposition of these points is not always very clear, and even serious students can expect some difficulty in these places.

Huygens' principle is introduced in some texts in a manner that can serve only to confuse further. But Rossi makes it the virtual foundation of his approach, discussing it rigorously, and then using it throughout the book as the basic tool to explain diffraction and interference phenomena. He includes a remarkably fine treatment of matters not generally covered in any detail in a text for advanced undergraduates, as the Cornu spiral, Fresnel integrals, zone plates, double refraction, the Fresnel double mirror, Lloyd's mirror, and interference in thin films.

Even so, the opening chapter which introduces this key principle will be found by some students to be unclear and difficult. It might have been somewhat more descriptive, leading on to a more rigorous treatment later.

If the instructor wants an optics text that also treats lens formulas, thick lenses, nodal points and back focal lengths, lens aberrations (astigmatism has but one short paragraph), and in general, the subject of geometrical optics, he should look elsewhere. Geometrical optics is treated by Rossi as an approximation in the application of Huygens' principle. But if a good background in optical theory on the basis of the wave model of light is wanted, with emphasis on interference and diffraction (142 pages on these topics specifically), then this book is excellent.

Rossi does not spare the rod in the subjects he considers essential to a solid basic training in optics. The problems are graded in difficulty from simple quantitative to sophisticated ones. There are answers to all odd-numbered problems, but an answer book for the instructor has all the solutions, a great comfort to many teachers.

Some of the problems are directly astronomical in nature; one, for instance, concerns constructing a Doppler curve for galactic rotation based on observations of 21-cm. radiation. In another problem, a fish quietly ponders the angular relationship of stars as seen from the bottom of a still pond. We are also asked to de-

termine the position and dimensions of the image of the sun in a steel ball bearing $\frac{1}{4}$ inch in diameter, a problem that has obvious application to a polished spherical earth satellite.

Optics is exemplary in its profuse use of diagrams; there are 360 illustrations, or three for every four pages. What a contrast to some old German texts which proudly announced on the cover, "Mit fünf Abbildungen!" There are excellent photographs of Fresnel and Fraunhofer diffraction patterns, of diffraction by circular and rectangular apertures, by a double slit, and by a straightedge.

The abundance of illustrations is more than matched by the number of equations, some 700, indicating the dependence of this subject on mathematical treatment.

Great care has been exercised in notation. The only factual errors noted were the date of the Michelson-Morley experiment (which should be 1887), and the statement that Jupiter's nearest satellite has a period of some 42 hours. This refers to Io, the innermost of the Galilean satellites; Jupiter's closest moon is its unnamed satellite No. V, with a 12-hour period.

Finally, there is a fine section on the aberration of light, the measurement of the velocity of light, and on phase and group velocity.

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NEW BOOKS RECEIVED

HISTORY OF MATHEMATICS, *David Eugene Smith*, 1958, *Dover*. Vol. I, 596 pages; Vol. II, 725 pages. $5.00 per set, paper bound.

Much information about early astronomers is contained in Professor Smith's lavishly illustrated account of the development of elementary mathematics from ancient times to the early 19th century. For example, two dozen of the men listed under A in the index were associated with astronomy closely enough to have lunar craters named after them.

The first edition of this classic appeared in 1923; the paper-bound version is a reprint of the 1951 edition. Vol. I is a general historical survey, while Vol. II traces special topics in more detail. They can be obtained separately at $2.75 each.

GEOPHYSICS AND THE IGY, *Hugh Odishaw* and *Stanley Ruttenberg*, editors, 1958, *American Geophysical Union*, 1515 Massachusetts Ave., N.W., Washington 5, D. C. 210 pages. $8.00.

In June, 1957, just before the International Geophysical Year began, the U. S. National Committee for the IGY held a symposium at Washington, D. C., where the 30 papers in this volume were presented. Brief, authoritative surveys are given of problems of the ionosphere, aurora, cosmic rays, artificial satellites, and other aspects of upper-atmosphere research; included also are contributions on oceanography and other earth sciences. The book is *Geophysical Monograph* No. 2 of the American Geophysical Union.

GLEANINGS FOR ATM's

CONDUCTED BY ROBERT E. COX

Herschelian Telescopes for Amateur Use

REFLECTORS of the Herschelian type are so uncommon nowadays that telescope makers are apt to suspect they have some serious defect. Actually, a properly designed Herschelian is a very effective instrument for the serious lunar or planetary observer. It has a minimum number of optical elements; there is no false color, no diffraction from spider or flat, and coma and astigmatism can be made negligible. The one drawback is an inconveniently long focal length, but there is a remedy for this.

Fig. 1a shows the original form of this telescope, as built by Sir William Herschel nearly 200 years ago. The mirror is tilted so that the image comes at one edge of the open end of the tube; there is no diagonal. Thus the mirror acts as if it were an off-axis portion of a larger one. Tilting the mirror will introduce much coma and astigmatism unless the focal length is very great. With a very long focus, the mirror can be spherical, a great advantage, since making an off-axis paraboloid requires a very experienced optical worker.

The objection to Herschel's design is that the observer is working at the open tube end, and air currents from his body spoil the seeing. Modern Herschelians avoid this problem by a small diagonal mirror that brings the focus out the side of the tube (Fig. 1b), as with a Newtonian telescope. The flat can be much smaller and placed closer to the focus than in ordinary Newtonians, because the cone of light is already displaced toward the side of the tube.

How long should a Herschelian be? The few American-built Herschelians I know of are f/15 to f/20. But this is not long enough, and an experienced observer will detect image defects, especially near the edge of the field.

The German telescope maker Anton Kutter, in his book *Der Schiefspiegler*, gives the following information:

"If one wants to use the Herschelian arrangement successfully (that is, hold astigmatism and coma so small that they do not cause perceptible image deterioration), a 10-centimeter mirror should be at least f/23, a 16-centimeter one f/27, and a 20-centimeter mirror at least f/30." The corresponding apertures in inches are 3.9, 6.3, and 7.9. Mr. Kutter continues:

"In 1916 the well-known mirror maker Bernhard Schmidt followed in Herschel's footsteps. To avoid the awkwardly long tube inherent in this design, he used the arrangement pictured here [Fig. 2]. The spherical mirror was 13 inches in aperture and had a focal length of 102 feet. Light was fed into this mirror by a siderostat, consisting of an equatorially mounted plane mirror. With this horizontal telescope, Schmidt obtained lunar and planetary photographs of outstanding quality."

Fig. 2 shows the layout of Schmidt's horizontal telescope. The flat is carried on a fork-type equatorial mounting, and reflects light horizontally toward the mirror, which is due south of the siderostat. The flat has to have at least $1\frac{1}{2}$ times the diameter of the primary mirror in order to observe objects north of the zenith

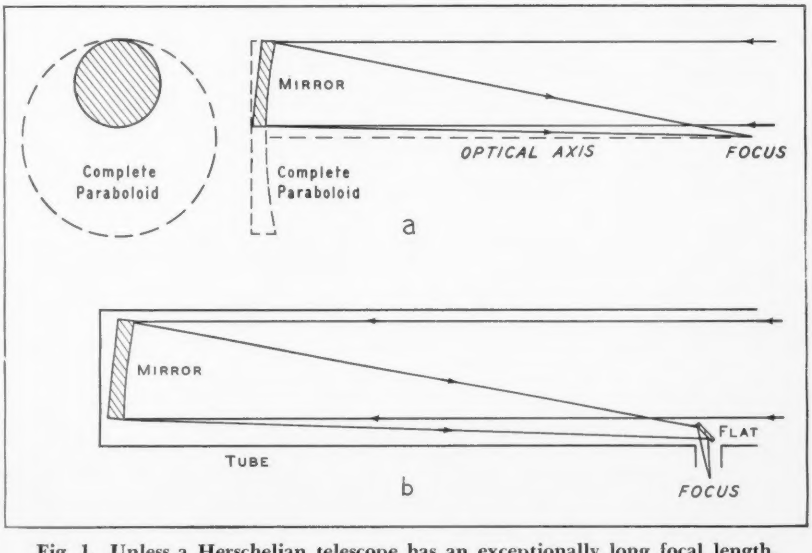


Fig. 1. Unless a Herschelian telescope has an exceptionally long focal length, its mirror must be an off-axis section of a complete paraboloid, as in Part a above. The focal ratio of the cone of light at the focus is equivalent to that of the full-size paraboloid, and must be allowed for in the choice of eyepieces. Part b shows the tube and diagonal flat.

without serious vignetting. The accuracy of the flat should be high, its surface perfect to 1/20 wave or better, if the best definition is sought.

Schmidt's telescope does eliminate the problem of mounting an exceptionally long tube, but unless thermal effects are minimized they can ruin image definition. The earth under the horizontal light path should be grass-covered, and the optical parts should be mounted high enough to avoid the steep temperature gradients just above the ground. A locality where the diurnal temperature variation is small would be advantageous.

It is not an easy task to construct a mirror of such long focus as Mr. Kutter recommends. The curve is only about 1/64" deep on an f/27 6-inch mirror, making the focal length hard to measure or control. Even though the surface is left spherical, it must be exceptionally smooth, and the longer the focus the more sensitive is the mirror to small changes. Customary tolerances of $\frac{1}{4}$ to 1/10 wave are not satisfactory; the mirror's figure must be perfect to within 1/25 wave or better, so even the faintest visible roughness of surface in the Foucault test cannot be tolerated.

The longer the radius of curvature of a mirror, the greater is the apparent magnification of surface defects in the Foucault test. It is this fact that makes the figuring of a long-focus mirror possible. However, a mirror of the focal ratio recommended by Mr. Kutter will subtend only a small angle, as seen during testing. Hence it will be helpful to view the Foucault pattern through a small telescope, placed just behind the knife-edge and focused on the mirror.

Another way to avoid the long tube of a standard Herschelian is the much more complicated Maksutov-Herschelian designed by Franklin B. Wright and described in *Amateur Telescope Making — Book Three,* page 574. This instrument, if properly built, has a very reasonable tube length, and provides images quite free from color, coma, and astigmatism. However, shaping and aligning the wedged correcting lens is a job for the more advanced amateur telescope maker.

R. E. C.

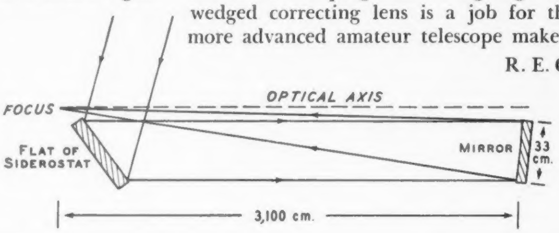


Fig. 2. The Herschelian telescope built by Bernhard Schmidt, with a fixed primary mirror and equatorially driven flat, was used very successfully for moon and planet photographs.

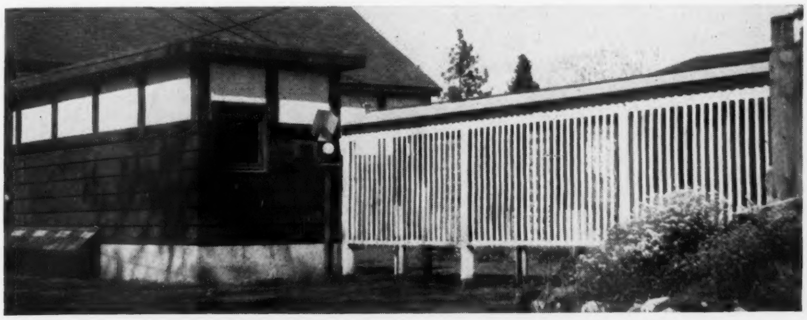
A New Solar Observatory in the Northwest

Since 1928 I have been studying the sun, and in 1951 I embarked on a project to build a telescope and spectrograph at my Northwestern Observatory in Spokane, Washington. In arriving at the equipment setup described here, I have had to make numerous changes, applying some 10,000 man hours and a like number of dollars to the project.

The station now ranks in size with many of the professional solar observatories. The sun's light is caught by a motor-driven siderostat mirror, then is reflected to a 15-centimeter long-focus mirror. Both the siderostat flat and the f/56 primary are figured to 1/20 wave length of light.

The siderostat beam passes through a properly proportioned, lattice-ventilated tunnel, which prevents the destructive heating effects usually encountered in a long horizontal path. The solar image, 7½ centimeters in diameter, may be studied in detail on an easily rotated screen, and drawings can be made of details in sunspots and other active regions.

The white-light plotting apparatus may then be swung out of the way, and light



The solar laboratory of B. C. Parmenter's Northwestern Observatory. Near the middle of the picture is seen the siderostat mirror, and to its right is the ventilated tunnel through which light passes to the focusing mirror. The beam is returned past the siderostat into the building at the left, which houses the observing room and the spectrographic apparatus.

from interesting active regions fed into a 14-foot spectrograph. It also operates at f/56, having a 52-millimeter grating ruled with 15,000 lines per inch and blazed for the first order in the red, where the dispersion at the hydrogen-alpha line is 3.5 angstroms per millimeter. This is a frequently used dispersion for solar studies at stations throughout the world.

The spectrograph is of the Hale astigmatic design, mounted on two piers: one of $3\frac{1}{2}$ tons carrying the headplate, the other of 500 pounds for the mirrors. There are three entrance slits, mounted on a rotating sector so that any one may be placed in use quickly. The first is a straight slit 12 millimeters long; the second is 45 millimeters; the third is a curved slit 32 millimeters long that matches the curvature of the solar limb. At the plate position there is a built-in focal-plane shutter, with a 35-mm. camera cassette, in which I use Hα film for prominences and flares.

Solar disk phenomena, such as plages, flares, and dark filaments, as well as prominences at the limb, are studied by means of Anderson rotating prisms that convert the apparatus into a spectrohelioscope.

The whole apparatus is kept in a nearly airtight enclosure, and whenever stratification of the air spoils the spectral seeing a fan is used to stir the air gently, as is necessary in all such horizontal arrangements. The spectrograph and observer's space require about 20 feet, and the length of the entire station is 45 feet.

An example of my spectrographic results is shown here. The light of the sun's photosphere is spread into its normal dark-line spectrum, and the hydrogen-alpha line is centered in the reproduction. Superimposed over much of the absorption line is a bright prominence, its internal motions causing widening toward the violet (left) and the red ends of the spectrum.

The spectrograph slit was set near the east limb of the sun; the lower part of the picture shows self-absorption in the bright prominence. Also seen are two patches of "surge" prominences, strongly shifted to the violet by a rapid motion toward the observer at about 90 miles per second.

During the past year we have been supplying observational data to the flare and prominence patrol program of the International Geophysical Year. I have been fortunate to receive advice in the design of the station from several well-known professional solar astronomers. The initial idea came from the late amateur astronomer, D. F. Brocchi, after whom the laboratory has been named.

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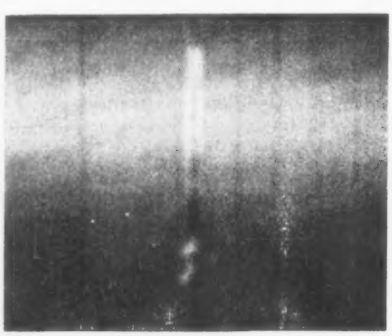

A solar spectrogram taken by Mr. Parmenter on April 29, 1958, at 20:55 Universal time, showing a bright hydrogen prominence against the spectrum of the solar disk and a small prominence over the east limb. Wave length decreases to the left.

UNIVERSAL TIME (UT)

TIMES used in Celestial Calendar are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. To obtain daylight saving time subtract 4, 5, 6, or 7 hours, respectively. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown.

CELESTIAL CALENDAR

Universal time is used unless otherwise noted.

MOON PHASES AND DISTANCE

Last quarter ...... September 6, 10:24
New moon .... September 13, 12:02
First quarter ..... September 20, 3:17
Full moon .... September 27, 21:43
Last quarter .... October 6, 1:20

September	Distance	Diameter
Apogee 2, 11^h	251,900 mi.	29′ 28″
Perigee 14, 17^h	223,400 mi.	33′ 14″
Apogee 29, 22^h	252,400 mi.	29′ 25″
October		
Perigee 13, 2^h	221,900 mi.	33′ 28″

MINIMA OF ALGOL

September 2, 8:36; 5, 5:25; 8, 2:13; 10, 23:02; 13, 19:51; 16, 16:39; 19, 13:28; 22, 10:16; 25, 7:05; 28, 3:54.

October 1, 0:42; 3, 21:31; 6, 18:19; 9, 15:08.

These minima predictions for Algol are based on the formula in the 1953 *International Supplement* of the Krakow Observatory. The times given are geocentric; they can be compared directly with observed times of least brightness.

MINOR PLANET PREDICTIONS

Eurydike, 75, 9.5. August 25, 23:55.1 −3-43. September 4, 23:49.2 −3-35; 14, 23:41.5 −3-33; 24, 23:33.3 −3-24. October 4, 23:26.4 −3-24; 14, 23:22.0 −3-06. Date of opposition, September 17.

Fides, 37, 9.9. August 25, 23:53.2 −2-39. September 4, 23:46.2 −3-14; 14, 23:37.8 −3-55; 24, 23:28.9 −4-37. October 4, 23:20.6 −5-14; 14, 23:14.0 −5-38. Date of opposition, September 16.

After the asteroid's name are its number and the magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1950.0) for 0^h Universal time. In each case the motion of the asteroid is retrograde. Data are supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.

VARIABLE STAR MAXIMA

September 3, RR Scorpii, 165030, 6.0; 6, T Centauri, 133633, 6.1; 13, V Canum Venaticorum, 131546, 7.1; 13, V Ophiuchi, 162112, 7.5; 14, RS Cygni, 200938, 7.4; 19, R Lyncis, 065355, 7.9; 21, Omicron Ceti, 021403, 3.7; 21, S Herculis, 164715, 7.6; 26, X Ophiuchi, 183308, 6.9.

October 5, R Sculptoris, 012233, 5.8; 6, R Bootis, 143227, 7.3; 6, RV Centauri, 133155, 7.6; 8, R Cygni, 193449, 7.3; 8, V Cassiopeiae, 230759, 7.9.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted magnitude.

COUNTERSUN OBSERVED

On the evening of June 27, 1958, about 8:00 p.m. Eastern daylight time, I saw a golden-brown glow in the sky directly opposite the sun. This glow, about four to six degrees in diameter, remained visible until the sun had completely set. At that time I was on a boat in the Atlantic and had an unobstructed horizon, the sky being clear except for a slight low-lying haze.

The glow in question appears to have been the anthelion or countersun, an infrequently observed optical effect in the atmosphere. It is described in M. Minnaert's book, *Light and Colour in the Open Air.*

STEPHEN GAUSS
50 Naugus Ave.
Marblehead, Mass.

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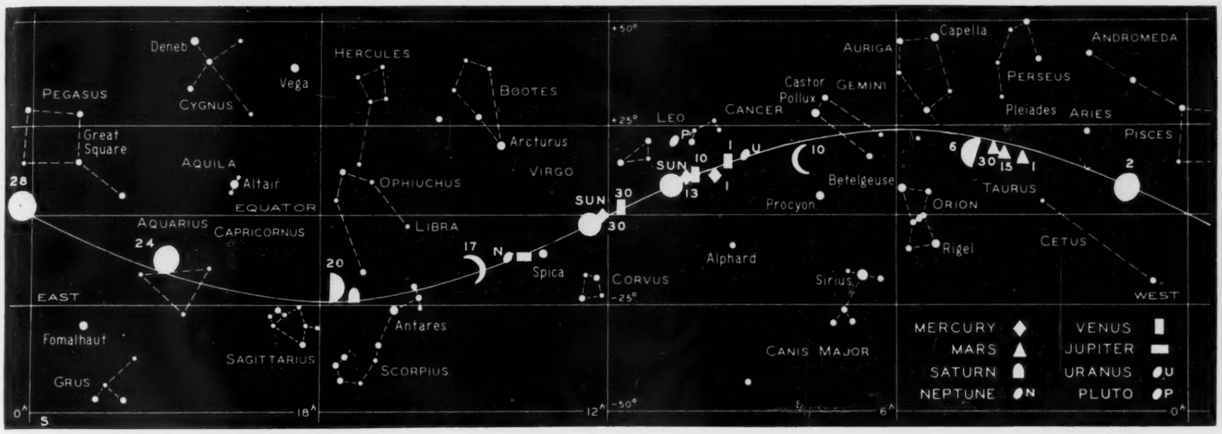


THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month or for other dates shown. All positions are for 0^h Universal time on the respective dates.

Mercury, in the morning sky, is favorably placed for observation from about September 5th, when it is in conjunction with Venus, to the 18th, when a second conjunction of these planets occurs. The chart on page 579 shows their paths for the first three weeks of the month. Greatest elongation of Mercury will take place on September 9th, when the planet will be 18° from the sun and will rise about $1\frac{1}{2}$ hours before it, at the beginning of astronomical twilight. This is a favorable elongation for observers who have never seen the elusive planet, particularly since it will form striking configurations with brilliant Venus.

Venus, of magnitude −3.3, is in Leo, rising about $1\frac{1}{4}$ hours before the sun in midmonth. In a telescope the almost full disk of the planet is 10″ in diameter. There are two conjunctions of Venus and Mercury this month, as described on page 579, and on September 8th Venus' path carries it less than a degree north of Regulus.

Earth arrives at heliocentric longitude 0° on September 23rd at 13:10 UT; autumn commences in the Northern Hemisphere, spring in the Southern.

Mars this month is a prominent object in Taurus, rising in the east about three hours after sunset. The planet increases half a magnitude in brightness during the month, from −0.6 to −1.1, as it approaches the earth. Telescopically, the disk enlarges from 12″.6 to 15″.7 during the same period. On September 4th at 20:56 UT, the moon will pass very near Mars; observers in Australia and southeast Asia will see the planet occulted.

Jupiter is visible low in the west after sunset in midmonth, when it sets about $1\frac{1}{2}$ hours after the sun. It is then at magnitude −1.3. The moon will be close to Jupiter on the morning of the 16th, and an occultation will be visible in Australasia. On the 26th Jupiter is in conjunction with Neptune, an event that should be visible in small telescopes. Jupiter passes 46′ south of 8th-magnitude Neptune.

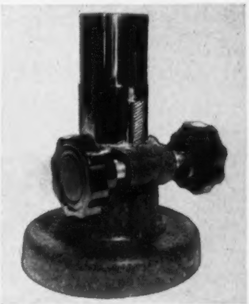
Saturn is in eastern quadrature on the 12th, crossing the meridian shortly before sunset and setting about 10:30 p.m. local time. In the telescope the +0.7-magnitude planet shows a disk 15″ in diameter, and the major axis of the ring system is 37″.6. The northern face of the rings is seen this year, tilted almost 27° to our line of sight.

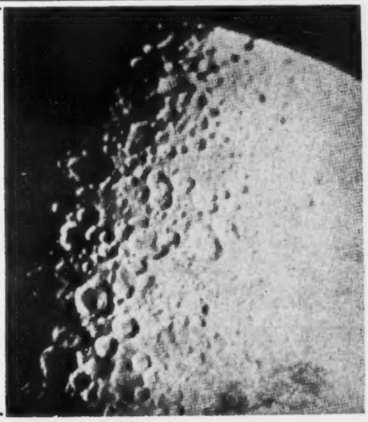
Neptune is an 8th-magnitude object in Virgo, just east of Jupiter. On the 15th it is at right ascension $14^h\ 05^m.6$, declination −10° 54′ (1958), and sets about $1\frac{3}{4}$ hours after the sun. Conjunction with Jupiter occurs on the 26th.

Uranus is a morning star in Cancer, at right ascension $9^h\ 08^m.2$, declination +17° 07′ (1958 co-ordinates) on the 15th. This 6th-magnitude object should be visible in binoculars at the beginning of morning twilight, low in the east.

Artificial satellite observations this month can be made with the help of a star chart from an August issue for evening twilight, from a January issue for morning.

W. H. G.





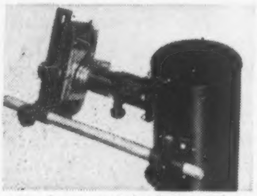
JUST REDUCED!

SATELLITE TELESCOPE

In setting the original price of our Satellite Telescope we figured amortization of tooling and engineering over 1,000 scopes. While sales haven't reached this point, because so many made their own instruments by using our unmounted optics, we have decided to take our loss on tool amortization and reduce the price. It's still the best satellite telescope available, so get yours now! Especially made for members of MOONWATCH. Gives you the greatest possible field with the ability to observe faint objects with only slight magnification. Wide (51-mm.) diameter, low-reflection-coated objective lens. A 6-element, extremely wide field, coated Erfle eyepiece, which in combination with the objective gives 5.5 power with a big 12° field and over 7-mm. exit pupil. This scope also makes a perfect wide-field finder — a wonderful comet seeker; see complete asterisms with it.

Stock #70,074-Y.................................$39.50 ppd.

Take Photos of the MOON Through Your Telescope with the EDMUND CAMERA HOLDER for TELESCOPES



Bracket attaches permanently to your reflecting or refracting telescope. Removable rod with adjustable bracket holds your camera over scope's eyepiece and you're ready to take exciting pictures of the moon. You can also take terrestrial telephoto shots of distant objects. Opens up new fields of picture taking!

SUN PROJECTION SCREEN INCLUDED

White metal screen is easily attached to holder and placed behind eyepiece. Point scope at sun, move screen to focus . . . and you can see sunspots!

All for the low, low price of $9.95

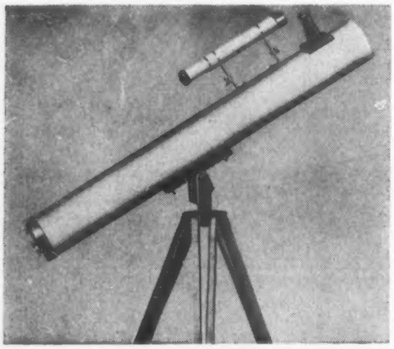
Includes brackets, 28¾" rod, projection screen, screws, and directions. Aluminum . . . brackets black crinkle painted.

Stock #70,162-Y.....................................$9.95 ppd.

Send check or money order — Money-back guarantee.

3" ASTRONOMICAL REFLECTOR

60 to 160 Power — An Unusual Buy!



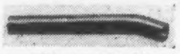
Assembled — ready to use! See Saturn's rings, the planet Mars, huge craters on the moon, star clusters, moons of Jupiter, double stars, nebulae, and galaxies! Equatorial-type mounting with lock on both axes. Aluminized and over-coated 3"-diameter f/10 primary mirror, ventilated cell. Telescope comes equipped with a 60X eyepiece and a mounted Barlow lens, giving you 60 to 160 power. A finder telescope, always so essential, included. Sturdy, hardwood, portable tripod.

Free with scope: Valuable STAR CHART and 272-page ASTRONOMY BOOK.

Stock #85,050-Y.................................$29.50 f.o.b.

(Shipping wt. 10 lbs.) Barrington, N. J.

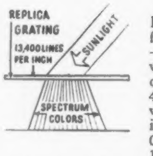
NEW HAND SPECTROSCOPE



Never before such a low price! Only possible because it employs newly developed replica-grating film — with 13,400 lines per inch. This grating is mounted in aluminum tube 4½" long, ½" diameter, with a fixed slit. Excellent for demonstrating spectrum; for seeing spectral lines of gases; for recognizing transmission and absorption bands of colored glasses, filters, dyes. Also will show more prominent Fraunhofer lines in the sun's spectrum.

Stock #30,280-Y..........................$2.50 ppd.

REPLICA GRATING Low, Low Cost



It's here — after decades of effort! Replica grating — on film — at very low price. Breaks up white light into full spectrum colors. An exciting display. 13,400 lines per inch, running long way on film 8" wide — grating area 7½". Thickness about 0.005". Dispersion about 24° in 1st order. Use it for making spectroscopes, for experiments, as a fascinating novelty. First time available in such a large size — so cheaply. Comes in clear-plastic protector.

Stock #40,267-Y....8" by 11" piece......$1.50 ppd.
Stock #50,180-Y....8" by 6' piece......$5.95 ppd.

Mounted Ramsden Eyepieces

Standard 1¼" Diameter

Our economy model, standard-size (1¼" O.D.) eyepiece. We mounted two excellent quality plano-convex lenses in black anodized aluminum barrels instead of chrome-plated brass to save you money. The clear image you get with these will surprise you. Directions for using short focal length eyepieces are included with both the ¼" and ½" models.

Stock #30,204-Y....¼" focal length....$4.75 ppd.
Stock #30,203-Y....½" focal length....$4.50 ppd.

OBSERVE SUNSPOTS

There are more sunspots now than for many a year. Join the International Geophysical Year effort of research on the sun. It's fun to use your telescope during broad daylight. Care must be taken to avoid damage to your eyes.

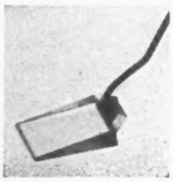
There are several methods of reducing intensity of the sun's rays, but the most popular is using a Herschel wedge plus a sun filter over the eyepiece.

UNMOUNTED HERSCHEL WEDGE

Size, 40 mm. x 55 mm.; wedge angle is 10°. The critical surface is flat to ¼ wave. Not mounted.

Stock #30,265-Y..$3.50

MOUNTED HERSCHEL WEDGE



Same size as above but mounted with diagonal holder for reflectors. Fits our rack-and-pinion holder. Stock No. 50,077-Y, that is also used on our 4¼" and 6" reflectors. Holder rod is long enough for 4¼", 6", and 8" mirrors. Rod is 5/32" diameter and 5" long.

Stock #30,266-Y....$5.50

SUN FILTERS

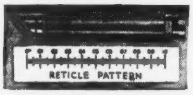
These filters help protect the eyes from normal visible rays, invisible infrared and ultraviolet. 3-mm. thickness. Per cent of light transmission: visible 0.0091%, ultraviolet none, infrared 0.0190%.

Stock No.	Size	Price
2726-Y	**1" x 1"**	**$1.00**
2727-Y	**2" x 2"**	**2.00**
2728-Y	**⅞" (round)**	**1.25**
2729-Y	**1¼" (round)**	**1.50**

INVITATION

VISIT OUR RETAIL STORE — (10 miles from Philadelphia — two miles from Exit #3 of the New Jersey Turnpike). When you're near us, stop in and see our big display. Our store contains many miscellaneous items at bargain prices.

50X MEASURING POCKET MICROSCOPE



Here is a handy little pocket instrument no longer than an ordinary fountain pen. Ideal for measuring and examining objects under 50X magnification. Reticle calibrated for measuring 1/10" by 0.001" divisions. Estimates to 0.0005" can easily be made. We check each one for accuracy before shipping. You make direct readings from reticle — no calculations necessary.

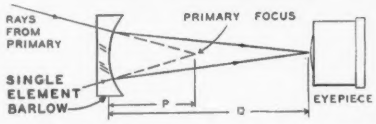
USE THIS MICROSCOPE FOR:

1. Glass surface inspection in mirror grinding and polishing.
2. Abrasive particle size determination and inspection.
3. Checking and measuring small parts for quality control.

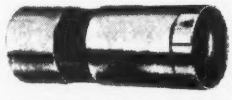
Chrome reflector at base of instrument reflects light on objects being examined or measured.

Stock #30,225-Y....................................$7.95 ppd.

DOUBLE AND TRIPLE YOUR TELESCOPE'S POWER WITH A BARLOW LENS



WHAT IS A BARLOW? A Barlow lens is a negative lens used to increase the power of a telescope without resorting to short focal length eyepieces, and without the need for long, cumbersome telescope tubes. Referring to the diagram above, a Barlow is placed the distance P inside the primary focus of the mirror or objective. The Barlow diverges the beam to a distance Q. This focus is observed with the eyepiece in the usual manner. Thus, a Barlow may be mounted in the same tube that holds the eyepiece, making it very easy to achieve the extra power. The new power of the telescope is not, as you might suppose, due to the extra focal length given the objective by the difference between P and Q. It is defined as the original power of the telescope times the quotient of P divided into Q.



Beautiful chrome mount. We now have our Barlow lens mounted in chrome-plated brass tubing with special spacer rings that enable you to vary easily the power by sliding split rings out one end and placing them in other end. Comes to you ready to use. Just slide our mounted lens into your 1¼" I.D. tubing, then slide your 1¼" O.D. eyepieces into our chrome-plated tubing. Two pieces provided, one for regular focal length eyepieces and one for short focal length ones.

Remember, in addition to doubling and tripling your power, a Barlow lens increases your eye relief and makes using a short focal length eyepiece easier.

Don't fail to try one of these. Many people do not realize the many advantages of a Barlow and the much greater use they can get from their telescopes. Our Barlow has a focal length of −1-5/16". We have received many complimentary letters about this lens. So sure are we that you will like it that we sell it under a 30-day guarantee of satisfaction or your full purchase price returned — no questions asked. You can't lose, so order today.

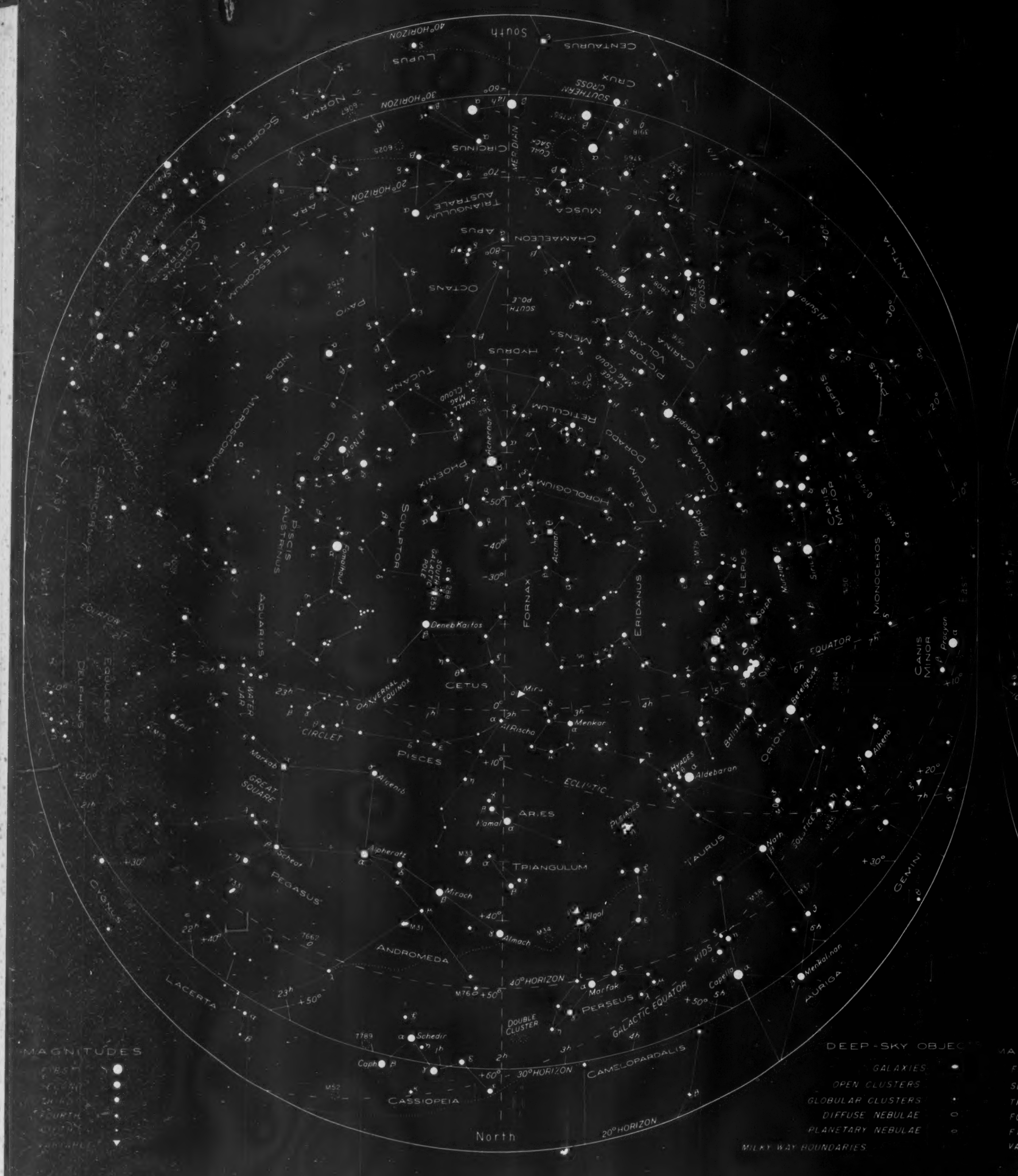
Stock #30,200-Y Mounted Barlow lens......$8.00 ppd

WAR-SURPLUS TELESCOPE EYEPIECE

Mounted Kellner Eyepiece, Type 3. 2 achromats, focal length 28 mm., eye relief 22 mm. An extension added, O.D. 1¼", standard for most types of telescopes. Gov't. cost $26.50.

Stock #5223-Y......$7.95 ppd.

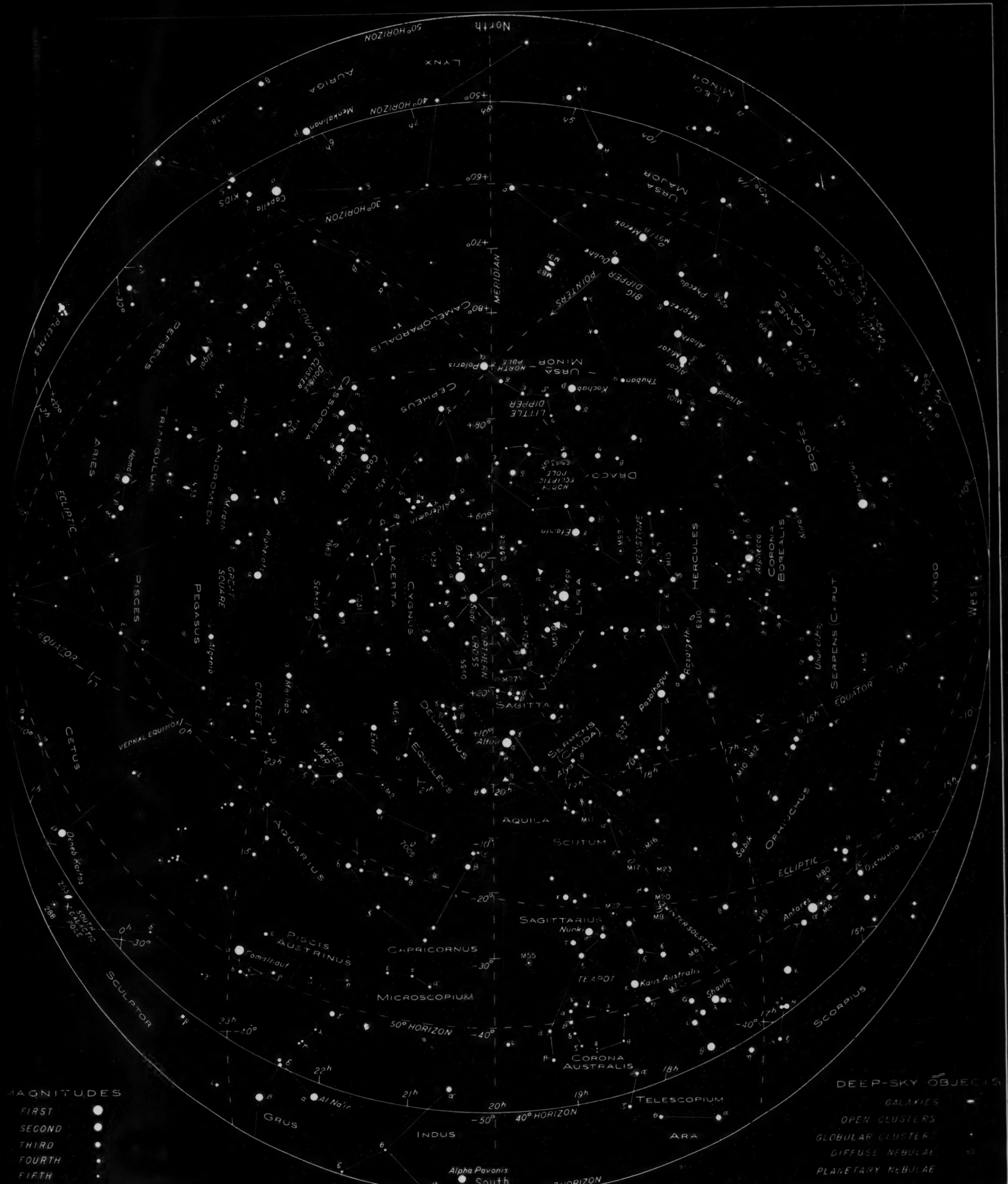
EDMUND SCIENTIFIC CO.



SOUTHERN STARS

The sky as seen from latitudes 20° to 40° south, at 11 p.m. and 10 p.m., local time, on the 7th and 23rd of November, respectively; also at 9 p.m. and 8 p.m. on December 7th and 23rd. For other dates, add or subtract ½ hour per week.

This is a good time of year to observe the Magellanic Clouds, both of which are near the meridian. Also look now for Phoenix and Fornax, with Eridanus winding down the sky to the east. Mira, in Cetus, is high; this famous variable is now near maximum light.



STARS FOR SEPTEMBER

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of September, respectively; also at 7 p.m. and 6 p.m. on October 7th and 23rd. For other dates, add or subtract ½ hour per week.

The Northern Cross is now on the meridian, while Lyra has moved into the western sky. Look for bright Deneb and Vega; south of these is Altair. The three form the "summer triangle." Near Altair are the inconspicuous constellations Sagitta, Delphinus, and Equuleus.

See pages 576 and 577.